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Planetary Entry Parachute Program
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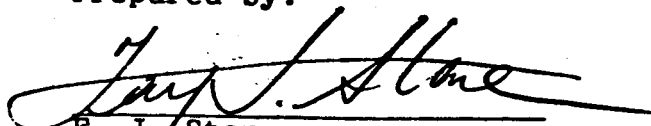
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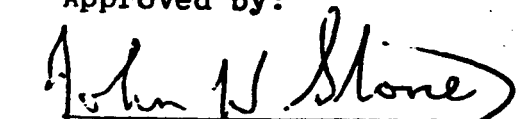
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ABSTRACT

The Planetary Entry Parachute Program 55-foot nominal diameter ringsail parachute design is analyzed with respect to material strengths, shock loading, and material stress analysis. This report summarizes calculations on which the design is based, material and joint test data, stress analysis procedures, and system weight and center of gravity location calculations. A materials properties section is also included and basic parachute system configuration and dimensions are defined.

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1.0 INTRODUCTION

This report is submitted in accordance with paragraphs 1.16 and 1.17 of Section B of the Work Statement contained in Martin Company Procurement Specification No. LY 152450, Revision E, dated August 3, 1967.

The subject parachutes were designed and manufactured under Martin-Marietta Corporation Contract No. RC7-709039.

2.0 DESIGN SPECIFICATION

The parachute system described in Martin Company Procurement Specification No. LY 152450 is for use in the balloon-launch phase of the Planetary Entry Parachute Program.

The system, as specified, consists of

- (a) parachute,
- (b) riser, bridle and fittings,
- (c) deployment bag, and
- (d) miscellaneous supporting hardware..

2.1 Parachute

The specified parachute is a ringsail type having the same basic geometric proportions as the 84-ft ringsail parachute, Pioneer Dwg. No. 1.562 except that the geometric porosity in the crown of the parachute is 0.8% to 1.0% of the nominal surface area. Material porosity is disregarded. The total geometric porosity is $15\% \pm 0.5\%$ of the nominal surface area of the parachute.

The parachute is as large as possible and has no reefing system. The weight of the parachute is no less than 70 lb and no more than 74 lb.

The color of the canopy is natural with a blue stripe on the inside that is approximately 6 in. wide at the skirt and tapers between the radials near the vent. Blue stripes approximately 3 in. by 12 in. are placed on the inside of the canopy skirt on both sides of all radials and at the center of the gore.

2.2 Riser System and Deployment Bag

The riser system and deployment bags are in accordance with Fig. 1, p. 8 of the specification (LY 152450). A knife

is attached to the main riser to cut the bag-mouth tie, which is at least 300-lb test line. A nylon conduit is added to one leg of the bridle to contain wires for a tension-measuring device. The deployment bag is lined with Teflon-coated fabric and has a petal-type opening and flaps to protect the riser during mortar ejection. The parachute is delivered packed in its deployment bag, which is suitable for firing in the 2-ft³-capacity Irving Type II mortar.

2.3 Deployment Conditions, Weight, and Miscellaneous Requirements

The specified payload weight is 600 lb, and the weight of the complete parachute system is no greater than 80 lb.

The parachute is capable of opening without structural failure at mach 1.6, dynamic pressure of 13 lb/ft², and a mortar ejection velocity of 130 ft/sec.

2.4 Miscellaneous Requirements

The complete parachute system, as specified, is capable of deployment and of sustaining opening loads without structural failure after being subjected to 125°C for 120 hr while packed.

All structural fabric material chosen for the parachute system is Dacron except the bridle (vehicle-attachment riser), which is nylon. All lines, tapes, webbings, and threads are heat-stabilized, high-elongation Dacron material; high-tenacity type was preferred. The canopy cloth's air permeability does not exceed 200 ft³/min/ft² at a pressure differential of 1/2 in. of water across the cloth. It was permissible to use MIL-C-25361, Type III Dacron webbing for the main riser. This is not a heat-stabilized webbing.

Each component part that can be disconnected from the system has an identifying serial number.

The system, packed for service, is shipped in a reusable container, which prevents the parachute pack from growing in size during shipping and storage. This container and any packing material is capable of the same sterilization treatment as the system. The container has a removable lid on one end and is cylindrical (inside diameter $11.5^{+0}_{-1/8}$ in., and $29.5^{+0}_{-1/8}$ in. long inside when the lid is fastened). The closed end has a threaded fitting which will accept an air fitting for the possible application of air pressure to eject the parachute. A $2^{+1/8}_{-0}$ -in.-wide slot extending $1^{+1/8}_{-0}$ in. below the inside of the fastened lid is cut into the cylindrical part of the container from the open end of the container.

3.0 DESIGN DATA

The parachute system was designed to meet the requirements given in Section 2.0 and consists of a parachute, main riser, vehicle-attachment riser (bridle), and a deployment bag.

The parachute is a 55-ft-nominal-diameter ringsail with 54 gores, and 65-ft-long suspension lines sewn onto six metal links.

The basic shape of the uninflated parachute is approximately a quarter-sphere.

The canopy has 10 rings and sails, of which sail 8 was omitted to form a 27-1/2-in. gap.

The total area of the canopy is 2376 ft^2 . Using a C_D of 0.62, the estimated drag area for the chute is 1473 ft^2 .

The total geometric porosity (λ_g) is 14.6%. The geometric porosity of the crown area (λ_{g_c}) is 0.94%.

4.0 GORE LAYOUT AND PARACHUTE CONFIGURATION

The parachute type, diameter, and geometric porosity were specified by Martin Company Procurement Specification No. LY 152450. The parachute requested was to be a ringsail type with a 55-ft-nominal-diameter and 15% geometric porosity. Pioneer selected a 54-gore configuration as the optimum.

The area S_o of the canopy was calculated from the equation

$$S_o = \frac{\pi}{4} \times D_o^2 = \frac{\pi}{4} \times 55^2 = 2376 \text{ ft}^2,$$

where D_o is the nominal diameter. The stipulated ringsail parameters were then applied to determine the diameter of the sphere on whose surface the required canopy area would subtend a 108° vertex angle (see Fig. 4-1).

4.1 Basic Gore Geometry

Ringsail parachutes have typically presented many problems arising from infolding at the skirt caused by the excess material required for fullness. To eliminate such excess, and thereby to minimize infolding, it was decided to increase the above-calculated canopy area in the ratio of 58:54 and to recalculate the sphere diameter accordingly. The gore parameters were then calculated as if the parachute were to have 58 gores. However, to keep to the proper canopy area, only 54 gores were assigned to each parachute.

Hence, the area used to calculate the radius of the sphere was

$$A = 2376 \times \frac{58}{54} = 2552 \text{ ft}^2.$$

Referring again to Fig. 4-1, we can see that

$$A = 2552 = 2\pi Rh$$

and we compute as follows.

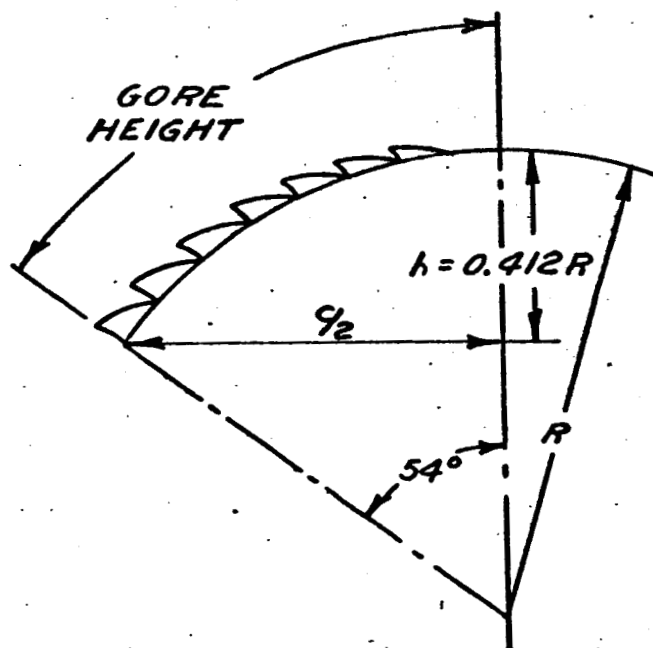


Fig. 4-1. Basic ringsail geometry.

$$h = 0.412R;$$

Substituting this value of h, we find

$$2552 = 0.824\pi R^2;$$

$$R^2 = \frac{2552}{\pi \times 0.824} ;$$

$$R = 31.397 \text{ ft.}$$

$$\begin{aligned} \text{Total height of gore} &= 31.397 \times 12 \times 54^\circ \text{ (radians)} \\ &= 355.09 \text{ in.} \end{aligned}$$

The method of calculating the basic gore dimensions and the resultant dimensions are illustrated in Fig. 4-2.

Following calculation of the basic gore dimensions, the number of sails was determined. It was decided to make the parachute with 10 sails, the upper four were actually rings separated by slots. The widths of the four slots, from the top down, were 1.5, 1.25, 1.0, and 0.75 in., respectively. To achieve the required 15% minimum geometric porosity, the 8th sail was omitted. All sails except sail 10 (which was 33 in. high) and all rings were 34 in. high (finished). Since the distance up the center of the gore was known for the leading and trailing edges of each sail (and ring), it was possible to calculate the gore width at all necessary points by straight-line interpolation between the closest two values taken from Fig. 4-2.

After the basic ring and sail dimensions were calculated, fullness was added. The basic ring and sail dimensions, with and without fullness, are shown in Table 4-1, and the fullness allowed is charted in Fig. 4-3.

Next, the pattern dimensions (including seam allowances) were calculated. The final pattern dimensions are summarized in Fig. 4-4.

TABLE 4-1
SAIL DIMENSIONS FOR THE 55-ft RINGSAIL

Sail no.	Lower edge				Upper edge			
	Height up gore, in.	Width, in.		Full-ness, %	Height up gore, in.	Width, in.		Full-ness, %
		With-out full-ness	With full-ness			With-out full-ness	With full-ness	
10	0	33.019	35.661	8.0	33.0	30.774	30.774	0
9	33	30.774	32.959	7.1	67.0	28.237	28.237	0
8	O M I T E D							
7	94.5	26.028	27.407	5.3	128.5	23.085	23.085	0
6	128.5	23.085	24.101	4.4	162.5	19.958	20.038	0.4
5	162.5	19.958	20.657	3.5	196.5	16.669	16.902	1.4
4	197.25	16.594	16.826	1.4	231.25	13.166	13.350	1.4
3	232.25	13.063	13.246	1.4	266.25	9.530	9.663	1.4
2	267.5	9.400	9.529	1.4	301.5	5.785	5.866	1.4
1	303.0	5.623	5.702	1.4	337.0	1.960	1.960	0

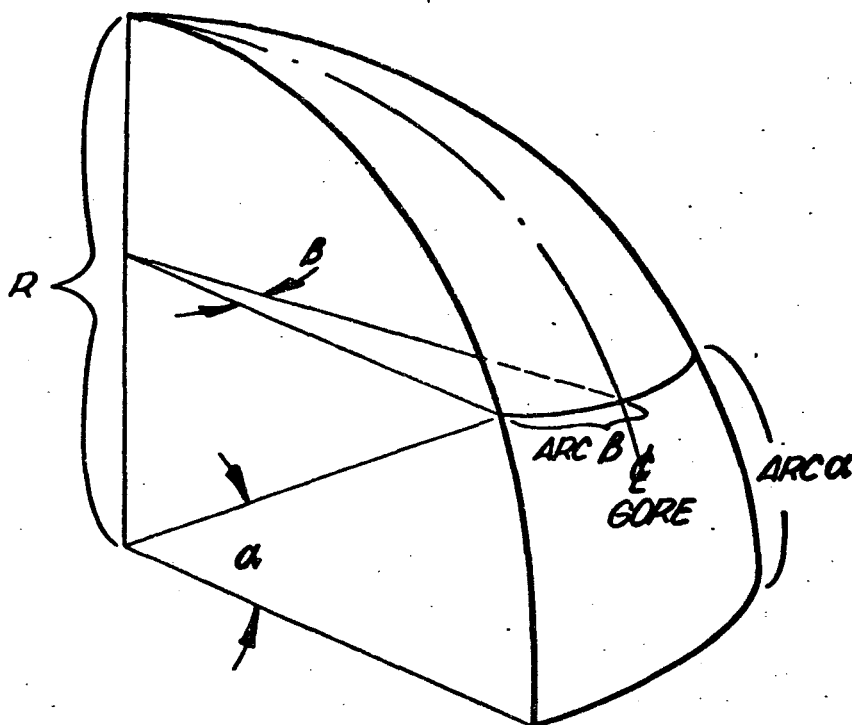
No. of gores	Area S_o , ft ²
54	2376
58	2552

$$R = 31.397 \text{ ft}$$

$$= 376.762 \text{ in.}$$

$$\beta = \frac{360}{2 \times 58} = 3.10344^\circ$$

$$= 0.054165 \text{ rad.}$$



α , deg	$\cos \alpha$	α , rad	Arc α , in.*	Arc α - 236.720 in.	Arc β , in.†	2 arc β , in.
90	0	1.5708	591.816	355.096	0	0
87°14.8'	0.04801	1.52276	573.720	337.000	0.980	1.960
85	0.0872	1.4835	558.927	322.207	1.780	3.559
80	0.1737	1.3963	526.073	289.353	3.545	7.090
75	0.2588	1.3090	493.182	256.462	5.281	10.563
70	0.3420	1.2217	460.290	223.570	6.979	13.959
65	0.4226	1.1345	427.437	190.717	8.624	17.248
60	0.5000	1.0472	394.545	157.825	10.204	20.407
55	0.5736	0.9599	361.654	124.934	11.706	23.411
50	0.6428	0.8727	328.800	92.080	13.118	26.236
45	0.7071	0.7854	295.909	59.189	14.430	28.860
40	0.7660	0.6981	263.720	26.298	15.632	31.264
36	0.8090	0.6283	236.720	0	16.510	33.019

*Arc α = $R\alpha$, where R is in inches and α is in radians.

†Arc β = $R\beta \cos \alpha$, where R is in inches and β is in radians.

Figure 4-2. Basic gore dimensions for the 55-ft ringsail.

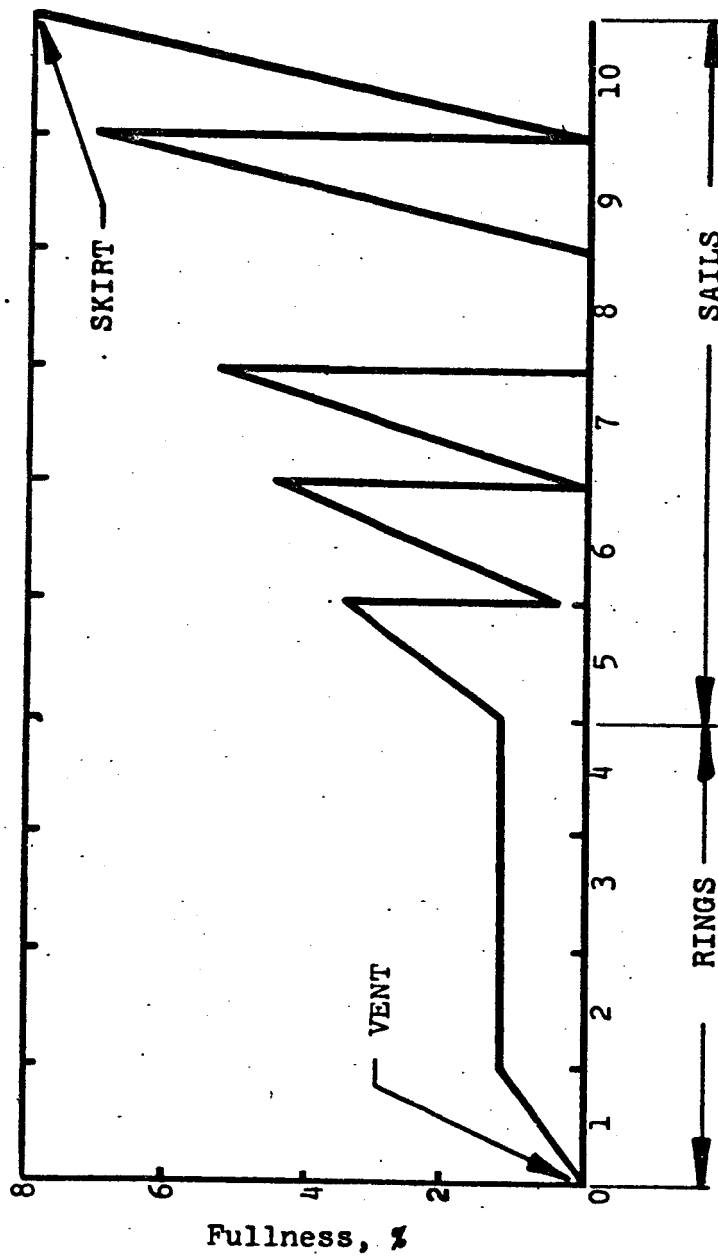
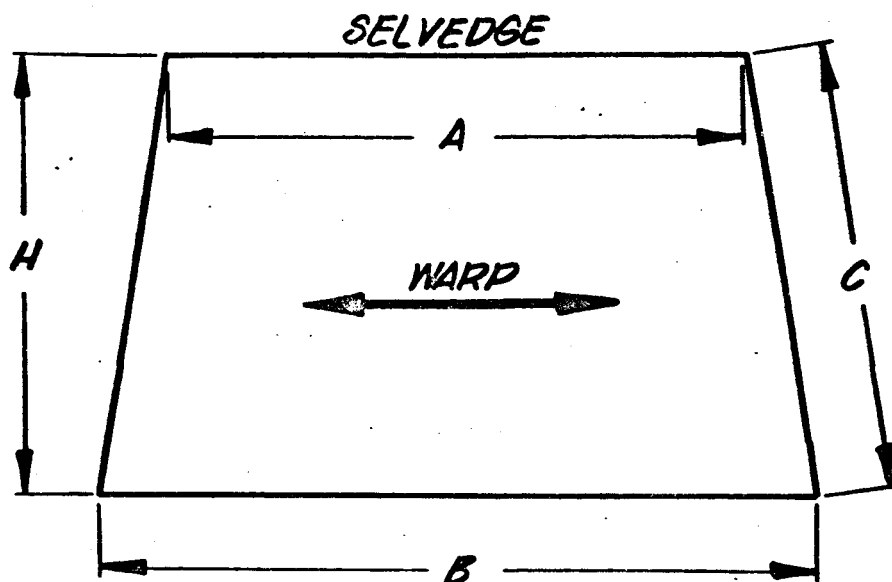


Figure 4-3. Fullness allowed on the 55-ft ringsail.



Sail	H	A	B	C
1	36.0	4.168	8.090	36.053
2	34.5	8.201	11.970	34.551
3	34.5	12.051	15.738	34.549
4	34.5	15.790	19.367	34.546
5	34.5	19.393	23.256	34.554
6	34.5	22.573	26.753	34.563
7	34.5	25.663	30.110	34.572
8	O M I T T E D			
9	34.5	30.888	35.746	34.585
10	34.5	33.461	38.642	34.597

Figure 4-4. Ring and sail patterns for the 55-ft ringsail. Dimensions are given in inches.

4.2 Geometric Porosity

This section presents the calculations required to yield a 55-ft-diam ringsail parachute with a total geometric porosity of 15%, and a crown-area geometric porosity of 0.90-0.95% as established by Martin Marietta. The method used is to determine the total area of a single gore (from the basic gore dimensions calculated by the method described in Section 4.1) and then to compare that area with the total open area in the gore.

To determine the total area of a gore, we assume that a gore comprises a number of trapezoids and a terminal triangle (at the vent end). Figure 4-5 (not to scale) illustrates how this assumption can be applied to the 55-ft parachute. All the dimensions shown are taken directly from the geometry calculations in para. 4.1 and are in inches.

The area of each trapezoid and the area of the triangle were calculated and summed to yield the total gore area.

The open area was calculated after the number of sails, their size, and the percentage of fullness allowed had been determined (see Section 4.1). The open area can be thought of as comprising four types:

- (a) the vent (the area covered by the vent lines must be subtracted from the total),
- (b) the slots in the crown area (assumed trapezoidal),
- (c) the 8th sail (which was omitted, leaving an assumedly trapezoidal gap surmounted by a sail scoop), and
- (d) the sail scoops (treated here as triangles).

In flight, the sail scoops will probably assume crescent shapes but may at any given time resemble anything from a thin crescent to an ellipse. Seventy-five percent of the triangular

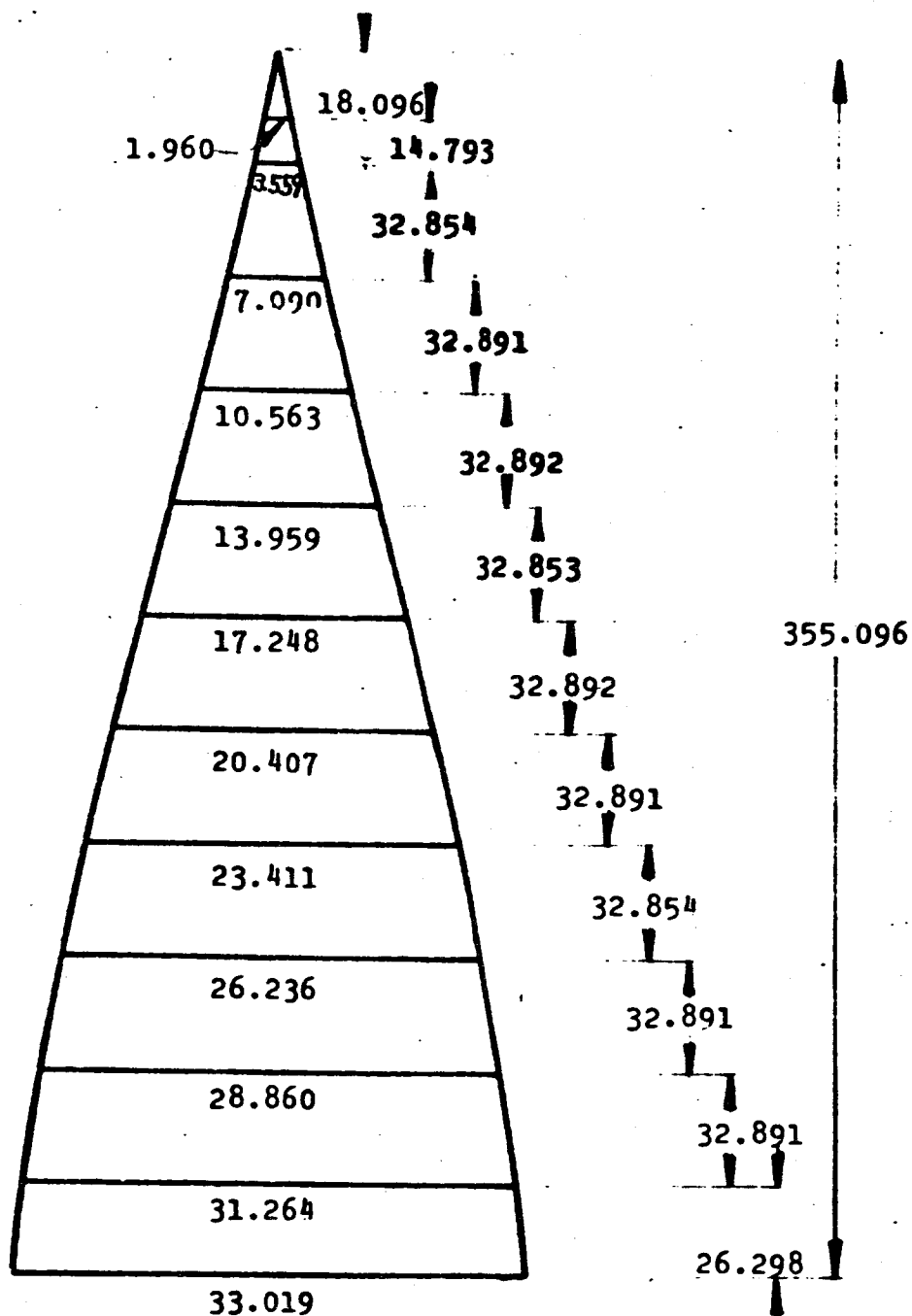


Figure 4-5. Basic gore of the 55-ft ringsail, for porosity calculations.

shape is taken as a reasonable approximation. Possible and assumed shapes are illustrated in Fig. 4-6.

Total geometric porosity λ_g (in percent) is calculated from the formula

$$\lambda_g = \frac{(\text{total open area}) \times 100}{(\text{total area})} \quad (4-1)$$

Crown-area geometric porosity λ_{g_c} (in percent) is calculated from the formula

$$\lambda_{g_c} = \frac{(\text{open area of vent} + \text{slots}) \times 100}{(\text{total area})} \quad (4-2)$$

The calculations made for the 55-ft-dia. ringsail parachute follow.

Total area of one gore (see Fig. 4-5 for dimension references).

$$\begin{aligned} & (26.298 \times 32.1415) + 32.891 (30.062 + 27.548 + 21.909 \\ & + 8.8265) + 32.854 (24.8235 + 5.3245) + 32.892 (18.8275 \\ & + 12.261) + (32.853 \times 15.6035) + (14.793 \times 2.7595) \\ & + (18.096 \times 0.980) = 6335.25 \text{ in}^2. \end{aligned}$$

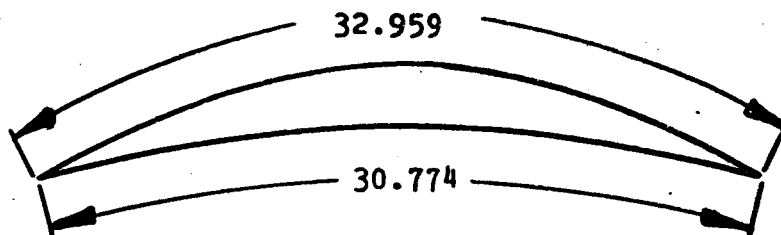
Total open area of one gore = (a) + (b) + (c) + (d),
where all dimensions are obtained from the ring and sail dimensions calculated in Section 4.1:

(a) Vent (less vent-line blockage)

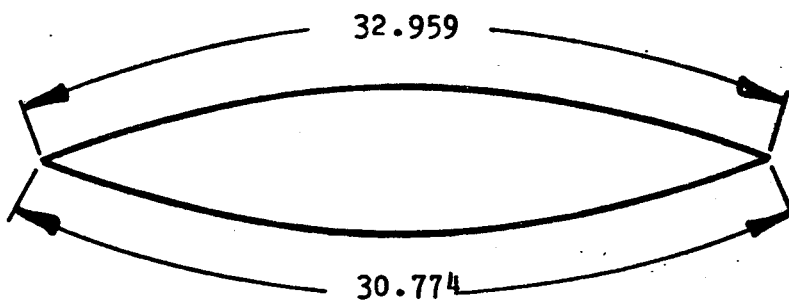
$$\begin{aligned} & \frac{1}{2} [(\text{base}) - (\text{vent-line blockage})] \\ & \times [(\text{alt.}) - (\text{vent-line blockage})] \\ & = \frac{1}{2} (1.96 - 0.15625) \times (18.096 - 0.3125) \\ & = 16.04 \text{ in}^2. \end{aligned}$$

(b) Slots (less radial-tape blockage)

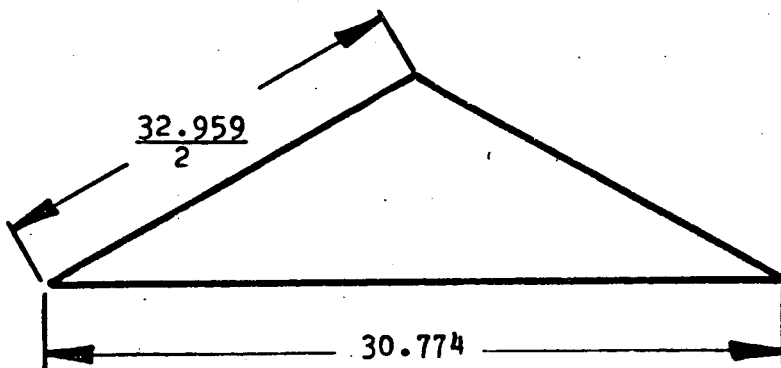
$$\begin{aligned} & (0.75 \times (16.864 - 0.75)) + (1.0 \times (13.298 - 0.75)) \\ & + (1.25 \times (9.596 - 0.75)) + (1.5 \times (5.784 - 0.75)) \\ & = 43.24 \text{ in}^2. \end{aligned}$$



(a) Probable actual shape



(b) Possible shape



(c) 75% of area of this shape assumed for porosity calculations

Fig. 4-6. Scoop shape. All dimensions are in inches and are taken from para. 4.1. They are for the trailing edge of sail 10 and the leading edge of sail 9.

From equation (4-2):

$$\text{Crown-area geometric porosity } (\lambda_{g_c}) = \frac{(a + b) \times 100}{\text{total area}}$$

$$\lambda_{g_c} = \frac{59.28 \times 100}{6335.25} = 0.94\% \text{ (see Fig. 4-7).}$$

(c) Omitted 8th sail (less radial-tape blockage) (see Fig. 4-8)

$$x_1 = [13.3285^2 - 12.639^2]^{\frac{1}{2}} = 4.23138;$$

$$\text{area}_1 = 27.5 \times \frac{1}{2} (27.487 + 25.278) + \frac{3}{4} (12.639 \times 4.23138) = 753.02 \text{ in}^2.$$

(d) Sail scoops (less radial-tape blockage) (see Fig. 4-9)

$$x_2 = [16.1045^2 - 15.012^2]^{\frac{1}{2}} = 5.83050;$$

$$\text{area}_2 = \frac{3}{4} (15.012 \times 5.8305).$$

$$x_3 = [11.6755^2 - 11.1675^2]^{\frac{1}{2}} = 3.40650;$$

$$\text{area}_3 = \frac{3}{4} (11.1675 \times 3.4065).$$

$$x_4 = [9.9535^2 - 9.644^2]^{\frac{1}{2}} = 2.46280$$

$$\text{area}_4 = \frac{3}{4} (9.644 \times 2.4628).$$

Total area of scoops:

$$= 111.99 \text{ in}^2.$$

Total open area:

$$16.04 + 43.24 + 753.02 + 111.99 = 924.29 \text{ in}^2.$$

Hence, from Eq. (4-1), the percentage of total open area,

λ_g is

$$\frac{924.29 \times 100}{6335.25} = 14.6\% \text{ (see Fig. 4-10).}$$

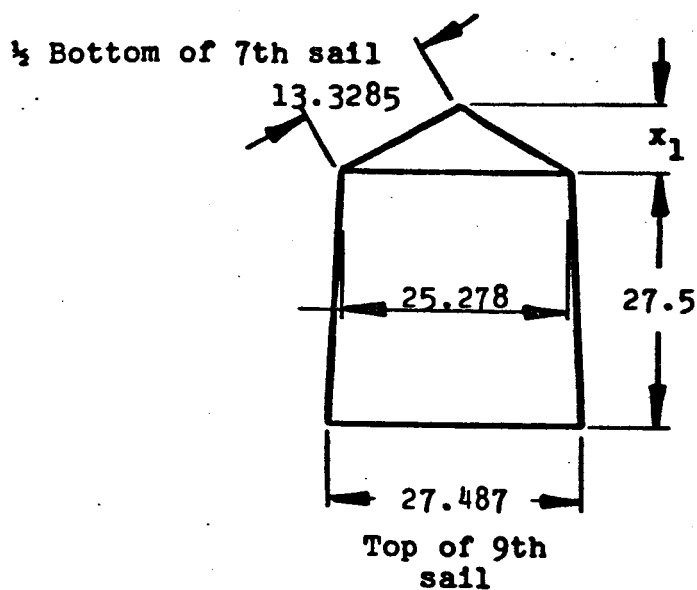


Fig. 4-8. Geometry of omitted 8th sail.

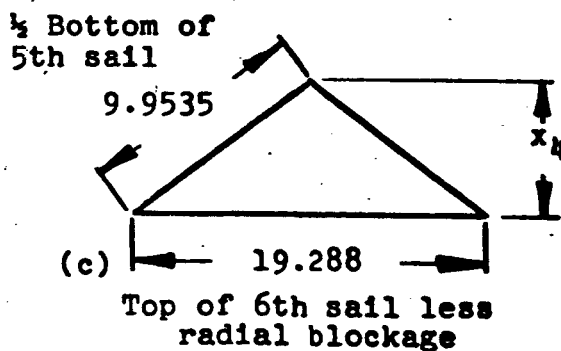
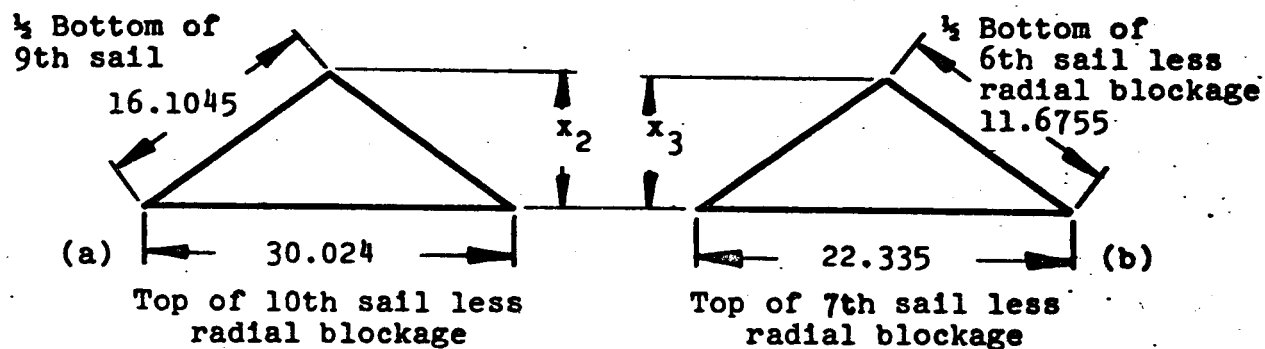


Fig. 4-9. Geometry of the sail scoops.

Open vent area = 16.04 in^2
 = $0.25\% S_o$

Open slot area = 43.24 in^2

Open area = 17.81 in^2

Open area = 28.53 in^2

Open area = 753.02 in^2

Open area = 65.6 in^2

Total area of basic gore
 from para. 4-2
 = 6335.25 in^2

Σ Open crown areas
 = 59.28 in^2

$$\lambda_{g_c} = \frac{5928}{6335.25} = 0.94\%$$

Σ Open areas = 924.29 in^2

$$\lambda_g = \frac{\Sigma \text{ open areas} \times 100}{\text{Total Area}}$$

$$= \frac{92429}{6335.25}$$

$$\lambda_g = 14.6\%$$

Fig. 4-10. Porosity distribution.

5.0 SNATCH FORCE (SEE FIG. 5-1)

$$v_t = \left(v_m^2 + 2as \right)^{1/2}$$

$$= (130^2 + 2 \times 32.2 \times 67.55)^{1/2}$$

$$= 145.8 \text{ ft/sec.}$$

$$P_s = \left[\frac{(W_c/g)v_t^2 \times (\text{no. of gores}) \times (\text{line strength})}{(l_s + l_r) \times (\% \text{ elongation})} \right]^{1/2}$$

$$= \left[\frac{(70/32.2) \times 145.8^2 \times 54 \times 605}{78 \times 0.30} \right]^{1/2}$$

$$= 8032 \text{ lb.}$$

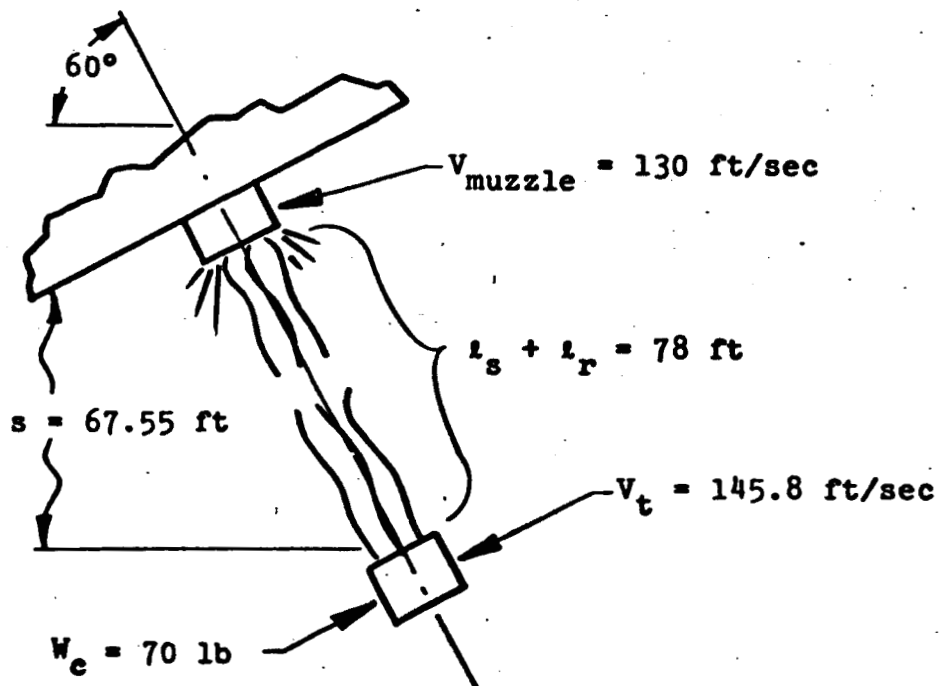


Figure 5-1. Design considerations for calculating snatch force at line stretch, due to mortar firing downward.

6.0 OPENING FORCE

Computed trajectories were available for a 65-ft-diam. ringsail with $C_D = 0.62$ and inflation time = 0.5 sec, at a dynamic pressure of 12 lb/ft^2 , and a 60-ft-diam. ringsail with $C_D = 0.62$ and inflation time = 0.5 sec, at dynamic pressures of 12 and 13 lb/ft^2 . These trajectories are included in Appendix A. When it was found that the maximum weight requirement necessitated a size reduction to 55-ft diam., the schedule did not permit time out for more computer work. In view of the available data, it was decided to scale down the maximum force obtained for the 60-ft parachute at 13 lb/ft^2 dynamic pressure in the same ratio as the differential between the 65- and 60-ft-diam. parachute forces at 12 lb/ft^2 . This value then became the predicted opening force for the 55-ft-diam. parachute. The calculations follow.

1. At 12 lb/ft^2

$$F_o \text{ for 65-ft parachute} = 20,547 \text{ lb}$$

$$F_o \text{ for 60-ft parachute} = 17,761 \text{ lb}$$

$$20,547 \times \left(\frac{60}{65}\right)^2 \times k = 17,761 \text{ lb}$$

$$k = \underline{1.01450.}$$

2. At 13 lb/ft^2

$$F_o \text{ for 60-ft parachute} = 18,580 \text{ lb}$$

$$F_o \text{ for 55-ft parachute} = 18,580 \times \left(\frac{55}{60}\right)^2 \times 1.01450$$
$$= \underline{15,838 \text{ lb.}}$$

7.0 PARACHUTE SIZING

The procurement specification required the parachute to be as large as possible to meet the specified deployment and weight conditions. Since the schedule did not permit waiting to obtain lighter-weight materials, it was necessary to use materials already in stock. Hence, the actual size of the parachute manufactured, 55-ft-nominal-diameter, was controlled by the weight limitation of 70-74 lb for the parachute.

8.0 STRESS ANALYSIS

The calculated margin-of-safety values are summarized in Fig. 8-1 and the design factors used are given in Table 8-1.

Ultimate suspension-line and vent-line load (see Fig. 8-1). There are 54 gores, each with an ultimate tensile strength of 605 lb. Estimated ultimate suspension-line load is

$$\begin{aligned} P_{ult} &= (\text{no. of gores}) \times (\text{ult. t.s./line}) \\ &= 54 \times 605 \\ &= 32,670 \text{ lb.} \end{aligned}$$

Allowable suspension-line load. The design factor of 1.995 is taken from Table 8-1. Estimated allowable suspension-line load is

$$\begin{aligned} P_{allow} &= \frac{P_{ult}}{\text{design factor}} \\ &= \frac{32,670}{1.995} \\ &= 16,376 \text{ lb.} \end{aligned}$$

Margin of safety for suspension lines.

$$\begin{aligned} \text{M.S.} &= \frac{\text{load allowable}}{\text{worst-case load developed}} - 1.0 \\ &= \frac{P_{allow}}{P_o} \\ &= \frac{16,376}{15,838} - 1.0 = 1.0340 - 1 \\ &= 0.0340 \text{ or } +3.40\%. \end{aligned}$$

Ultimate radial-member load. Assume that all radial loads are carried by 54 radial tapes in tension (i.e., the canopy cloth does not carry any radial load).

$$\begin{aligned} P_{ult} &= (\text{no. of radial tapes in tension}) \\ &\quad \times (\text{ult. t.s./tape}) \\ &= 54 \times 550 = 29,700 \text{ lb.} \end{aligned}$$

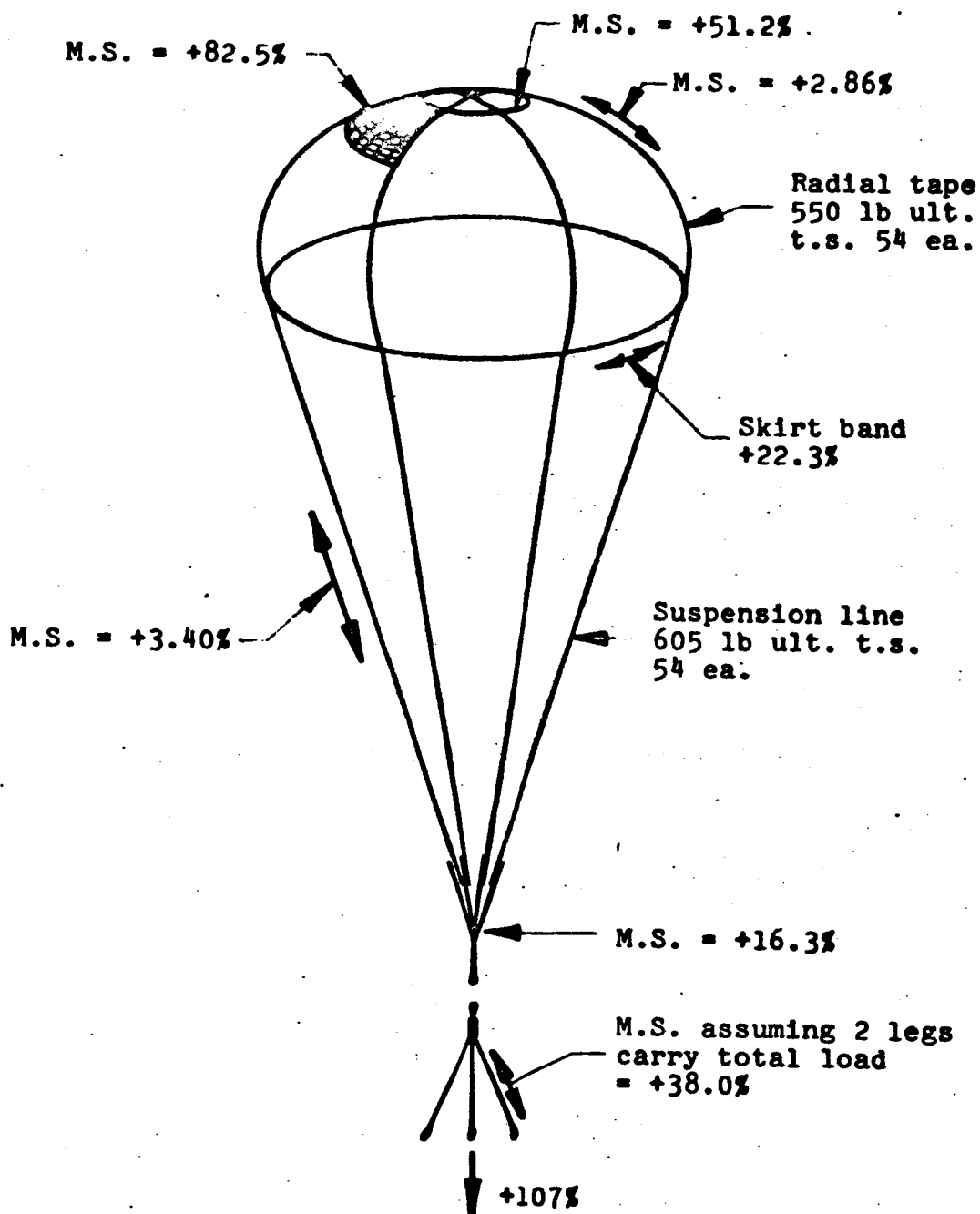


Fig. 8-1. Design of the 55-ft-dia. 54-gore ringsail parachute. (Pioneer drawing 1.5438.)

TABLE 8-1
STRENGTH-LOSS AND SAFETY FACTORS

Symbol	Function	Main seams, rings and sails	Radial tape	Susp. lines	Upper riser	Bridle	Vent band and tape splices
m	Joint efficiency	0.80	1.00	0.95	0.80	0.93	0.95
n	Heat loss	0.90	0.90	0.90	0.90	1.00	0.90
a	Abrasion	0.96	0.96	0.96	0.96	0.96	0.96
j	Safety factor	1.50	1.50	1.50	1.50	1.50	1.50
c	Line convergence	N/A	N/A	1.04	N/A	1.04	N/A
f	Asymmetrical loading	1.05	1.05	1.05	1.05	1.05	1.05
Design factor $\frac{1cf}{mnl}$		2.279	1.823	1.995	2.28	1.83	1.92

Allowable load for radial members. The design factor of 1.95 is taken from Table 8-1.

$$\begin{aligned}P_{\text{allow}} &= \frac{P_{\text{ult}}}{\text{design factor}} \\&= \frac{29,700}{1.823} \\&= 16,292 \text{ lb.}\end{aligned}$$

Margin of safety for radial members.

$$\begin{aligned}\text{M.S.} &= \frac{\text{load allowable}}{\text{worst-case load developed}} - 1.0 \\&= \frac{P_{\text{allow}}}{P_o} - 1.0 \\&= \frac{16,292}{15,838} - 1.0 \\&= 0.0286 \text{ or } 2.86\%.\end{aligned}$$

CALCULATE LOAD ACTING ON MAIN SEAM.

EXPLANATION OF TABLE 8-2

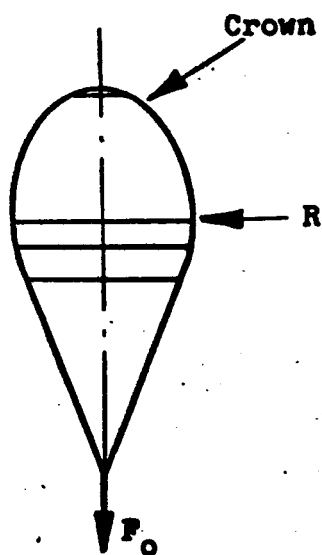
1. For selected rings, determine (2) cloth area including fullness, less seam allowance and take-up.
2. From spherical coordinates of basic gore dimensions, we obtain total area of crown for combination of ring selected.
3. Assuming that crown inflates with a hemispherical profile (a good assumption since evaluation of ringsail parachute profiles indicate the profile is very close to a hemisphere), we calculate a radius.
4. From Fig. 8-2, for a given radius, we determine the corresponding force. (A good method since comparison of ringsail profile to force indicates our assumption of loads vs profile for this configuration is good.)
5. By dividing the force by the cloth area that the force acts on, we can determine the pressure acting on the selected rings.
6. By taking the product of the pressure and radius, we obtain a load in lb/in. at a given point on the main seam. Worst case is for case 4, where load is 14.428 lb/in. = P_{dev} . Assume maximum load is carried by cloth above gap.

Allowable load for canopy cloth.

$$\begin{aligned} P_{allow} &= \frac{\text{ult strength cloth (warp)}}{\text{design factor}} \\ &= \frac{60 \text{ lb/in.}}{2.279} \\ &= 26.33 \text{ lb/in.} \end{aligned}$$

Margin of safety for cloth.

$$\begin{aligned} \text{M.S.} &= \frac{P_{\text{allow}}}{P_{\text{dev}}} - 1.0 = \frac{26.33 \text{ lb/in.}}{14.428 \text{ lb/in.}} - 1.0 \\ &= 1.825 - 1.0 \\ &= +82.5\%. \end{aligned}$$



Apportion F_o to canopy shape, during inflation process, to determine worst case for load on main seam.

TABLE 8-2
CANOPY LOADING

1	2	3	4	5	6	7
Case no.	Cloth area including fullness, less seam allow. and take-up, in ²	Area of crown, in ²	Radius in.	F_o lb	5 ± 2 lb/in ²	6×4 lb/in.
1	21,166	22,338	59.625	1230	0.05811	3.465
2	69,898	71,775	106.880	6050	0.08655	9.250
3	144,897	145,621	152.238	13180	0.09096	13.848
4	191,249	190,723	174.225	15838	0.08281	14.428
5	247,427	285,234	213.064	13900	0.05617	11.968
6	306,620	342,104	220.00 (= D_p)	13550	0.04419	9.722

FORCE VALUES CALCULATED AS FOLLOWS:
(SEE SECTION 6.0 DETAILS REPORT)

$$FORCE(55 FT. D.) = FORCE(40 FT. D.) \times \left[\frac{55}{60} \right]^2 \times 1.0145$$

[FROM COMPUTER]

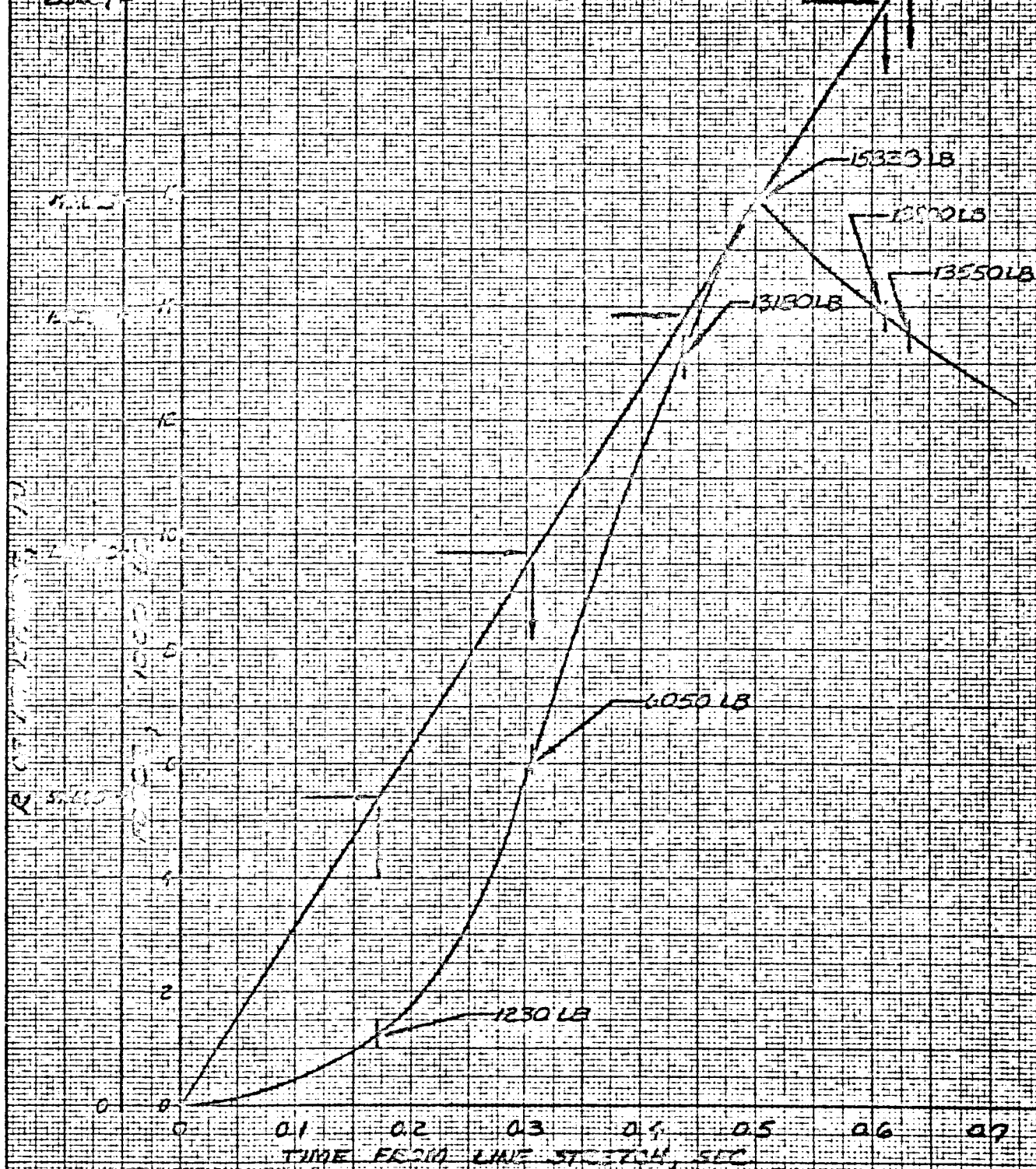
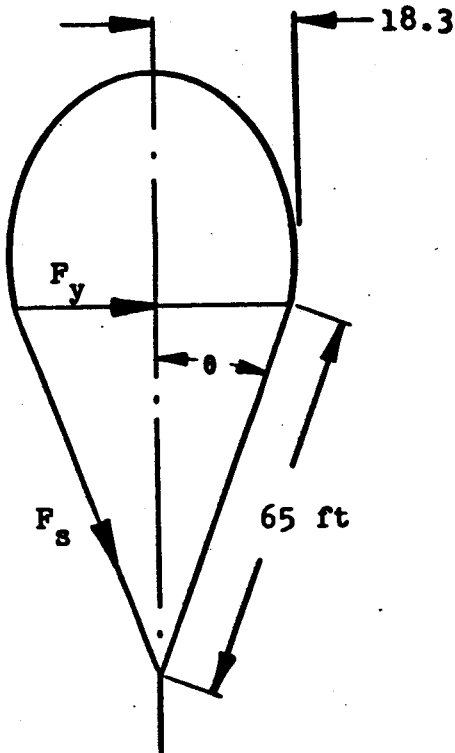


FIGURE D-2 INFLATED EDGECUTTE BEHAVIOR AND FORCE VS. TIME

Load developed in skirt band.



Determine θ

$$\sin \theta = \frac{18.3}{65}$$

$$= 0.28153$$

$$= 16^\circ 21'$$

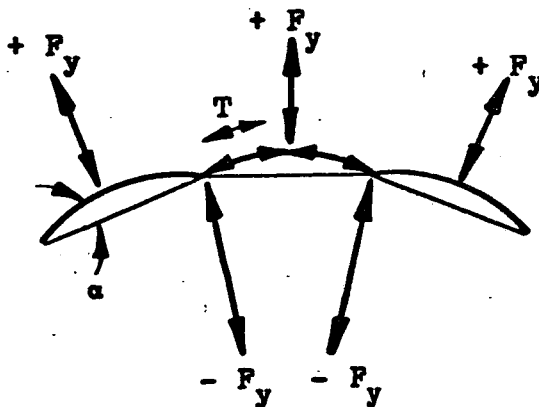
Calculate F_y

$$F_y = F_s \sin 16^\circ 21'$$

$$= 293.3 \times 0.28153$$

$$= 82.6 \text{ lb}$$

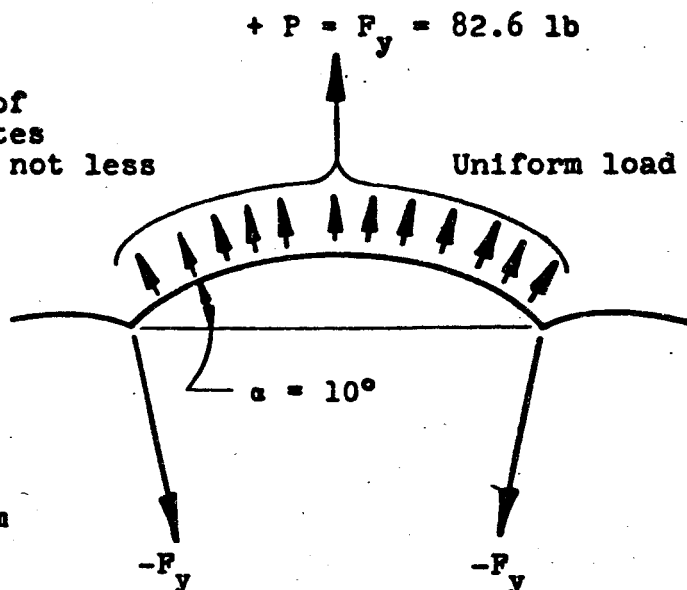
$$\begin{aligned} F_s &= \frac{F_o \text{ max}}{\# \text{ lines}} \\ &= \frac{15,838}{54} \\ &= 293.3 \text{ lb} \end{aligned}$$



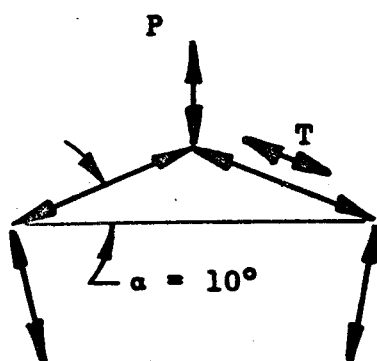
For convenience, we assign F_y forces acting toward the C/L of the parachute-values and + values to the forces acting outward on the cloth panels.

The tension force (T) in the skirt band is a function of the force $+ F_y$ and the α taken by the scallop at the skirt.

NOTE: From evaluation of inflated parachutes α appears to be not less than 10° .



Free-body Diagram



$$\begin{aligned}
 P_{\text{dev}} &= T = \cot \alpha \frac{P}{2} \\
 &= 5.671 \times \frac{82.6}{2} \\
 &= 234.21
 \end{aligned}$$

Allowable load in skirt band

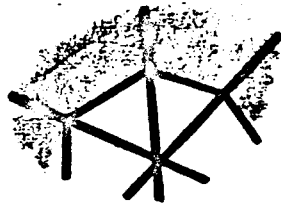
$$\begin{aligned}
 P_{\text{allow}} &= \frac{\text{ult. t.s. tape (rated)}}{\text{Design Factor}} \\
 &= \frac{550 \text{ lb}}{1.92} \\
 &= 286.4
 \end{aligned}$$

Margin of safety for skirt band

$$\begin{aligned}
 \text{M.S.} &= \frac{P_{\text{allowable}}}{P_{\text{developed}}} - 1.0 \\
 &= \frac{286.4}{234.2} - 1.0 = 1.223 - 1.0 = \underline{+22.3\%}
 \end{aligned}$$

Load developed in vent band.

From calculation for skirt band, $F_y = 82.6$ lb. Using a vent tape 7% shorter than constructed diameter of the vent, we are able to carry at least 20% of the F_y load in the vent tape.



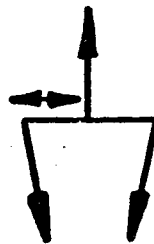
Cloth

Radial Member

Vent Band

Vent Tape (or line)

Free-body Diagram



$$\begin{aligned} F_{\text{vent}} &= F_y \times .80 \\ &= 66.08 \text{ lb} \end{aligned}$$

Use the following formula

We solve for P_{dev}

$$\begin{aligned} P_{\text{dev}} &= \frac{F_{\text{vent}}}{2 \sin \frac{360^\circ}{2(\text{\#gores})}} \\ &= \frac{66.08 \text{ lb}}{2 \sin \frac{360^\circ}{2 \times 54}} \\ &= \frac{66.08}{2 \sin 3.33^\circ} \\ &= \frac{66.08}{0.11628} = 568.28 \text{ lb} \end{aligned}$$

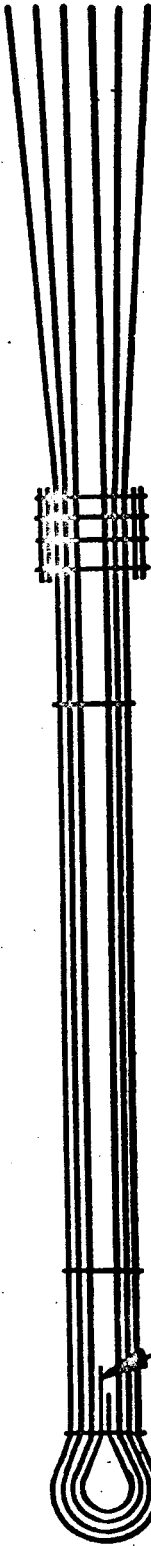
Load allowable for vent band

$$\begin{aligned} P_{\text{allow}} &= \frac{\text{ult. t.s. tape}}{\text{Design Factor}} \\ &= \frac{3 \times 550 \text{ lb}}{1.92} = 859.4 \text{ lb} \end{aligned}$$

Margin of safety for vent band

$$\begin{aligned} \text{M.S.} &= \frac{P_{\text{allowable}}}{P_{\text{developed}}} - 1.0 = \frac{859.4}{568.28} - 1.0 \\ &= 1.512 - 1.0 = +51.2\%. \end{aligned}$$

Attached Riser, Pioneer Dwg. 3.73454



Load Allowable

$$P_{\text{allowable}} = \frac{6\text{ply} \times 7000 \text{ lb}^*}{\text{Design Factor}}$$

*rated strength for MIL-W-25361, Type III

$$= \frac{42,000}{2.28} = 18421$$

Margin of Safety

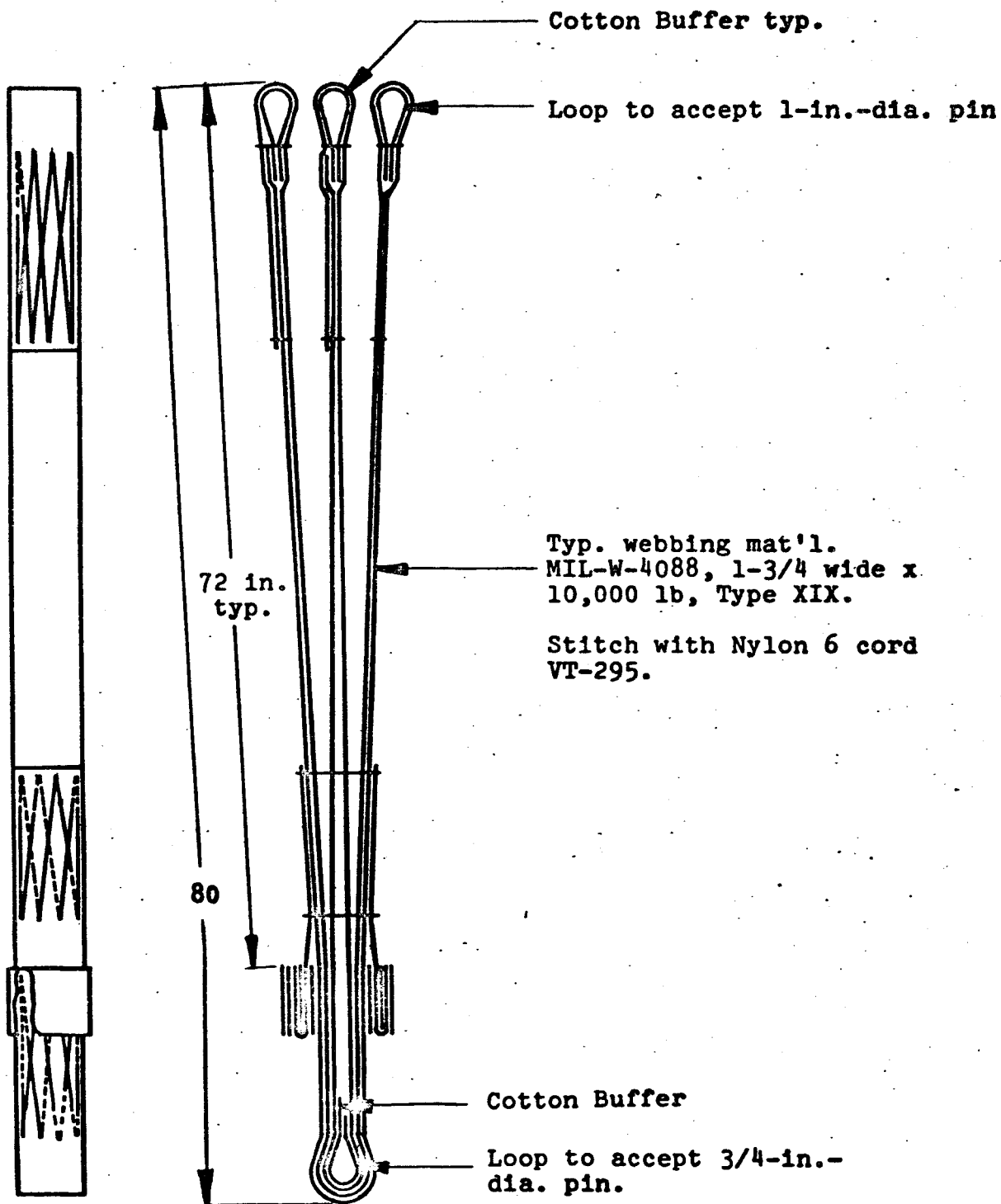
$$\text{M.S.} = \frac{P_{\text{allow}}}{P_{\text{dev}}} - 1.0 \quad P_{\text{dev}} = F_o$$

$$= \frac{18,421}{15,838} - 1.0$$

$$= 1.163 - 1.0 = +16.3\%$$

Cotton Buffer

4 point



Calculate P_{allow} on two legs

$$P_{all} = \frac{4\text{ply} \times 10,000 \text{ lb/ply}}{\text{Design Factor}} = \frac{40,000}{1.83} = 21,858 \text{ lb}$$

Calculate Margin of Safety (Two Legs)

$$\text{M.S.} = \frac{P_{all}}{F_{o\max}} - 1.0 = \frac{21,858}{15,838} - 1.0 = 1.380 - 1.0 = 38.0\%$$

Calculate P_{allow} (Equal Load)

$$P_{all} = \frac{6 \text{ ply} \times 10,000 \text{ lb/ply}}{\text{Design Factor}} = \frac{60,000}{1.83} = 32,787 \text{ lb}$$

Calculate M.S. (Equal Load)

$$\begin{aligned} \text{M.S.} &= \frac{P_{all}}{F_o \text{ max}} - 1.0 = \frac{32,787}{15,838} - 1.0 = 2.070 - 1.0 \\ &= +107\%. \end{aligned}$$

9.0 WEIGHT BREAKDOWN

The weight of the complete parachute system supplied by Pioneer Parachute is 77.25 lb and is itemized in Table 9-1. This value meets the 80-lb maximum weight requirement. The parachute itself weighs 70.5 lb and meets the 70-lb minimum-weight requirement.

The attached riser weighs 2 lb, the vehicle-attachment riser (bridle) weighs 3.063 lb and the deployment bag weighs 1.688 lb.

**TABLE 9-1
WEIGHT BREAKDOWN**

Item	Qty. (yd or yd ²)	Unit weight (oz/yd or oz/yd ²)	Total weight (lb)
1.0 Parachute			
1.1 Cloth	275	2.0	33.564
1.2 Radial tapes	532	0.26	8.645
1.3 Skirt reinforcing	55	0.26	0.887
1.4 Vent reinforcing	9	0.26	0.146
1.5 Suspension lines	1182	62 yd/lb	19.063
1.6 Vent lines	30	62 yd/lb	0.488
1.7 Ring and sail reinforcements	456	0.16	4.560
1.8 Blue striping	6	1.10	0.408
1.9 Radial-loop buffer	9	0.14	0.079
1.10 End fittings	6ea	~1-3/4 oz ea	0.684
1.11 Thread		approximately	2.000
<u>SUB TOTAL - ACTUAL</u>			<u>70.50</u>
2.0 Attached Riser			<u>2.00</u>
3.0 Vehicle-attachment Riser (Bridle)			<u>3.063</u>
4.0 Deployment Bag			<u>1.688</u>
<u>TOTAL WEIGHT</u>			<u>77.25</u>

10.0 CENTER OF GRAVITY

10.1 Packed Parachute

The center of gravity of the packed parachute is assumed to be at the center of the deployment bag.

10.2 "Strung-out" Parachute

The weight breakdown for the center-of-gravity calculations for the "strung-out" parachute is shown in Fig. 10-1 and the locations for the weights and the center-of-gravity are given in Fig. 10-2.

The calculations are shown in Table 10-1.

10.3 Inflated Parachute

The weight breakdown for the center-of-gravity calculations for the inflated parachute is shown in Fig. 10-1, and the locations for the weights and the center of gravity are given in Fig. 10-3.

The calculations are shown in Table 10-2. The center of gravity of the included air mass is as follows.

$$r = 18.838 \text{ ft}$$

$$\text{c.g.} = (3/8)r + 903.02 \text{ (from Fig. 10-3)} = 987.79 \text{ in.}$$

The weight of the included air mass is as follows.

$$w = \rho \times (2/3)\pi r^3$$

at 128,000 ft altitude

$$w = 0.125 \text{ lb.}$$

**Figure 10-1. Weight Breakdown
for Center-of-Gravity Calculations**

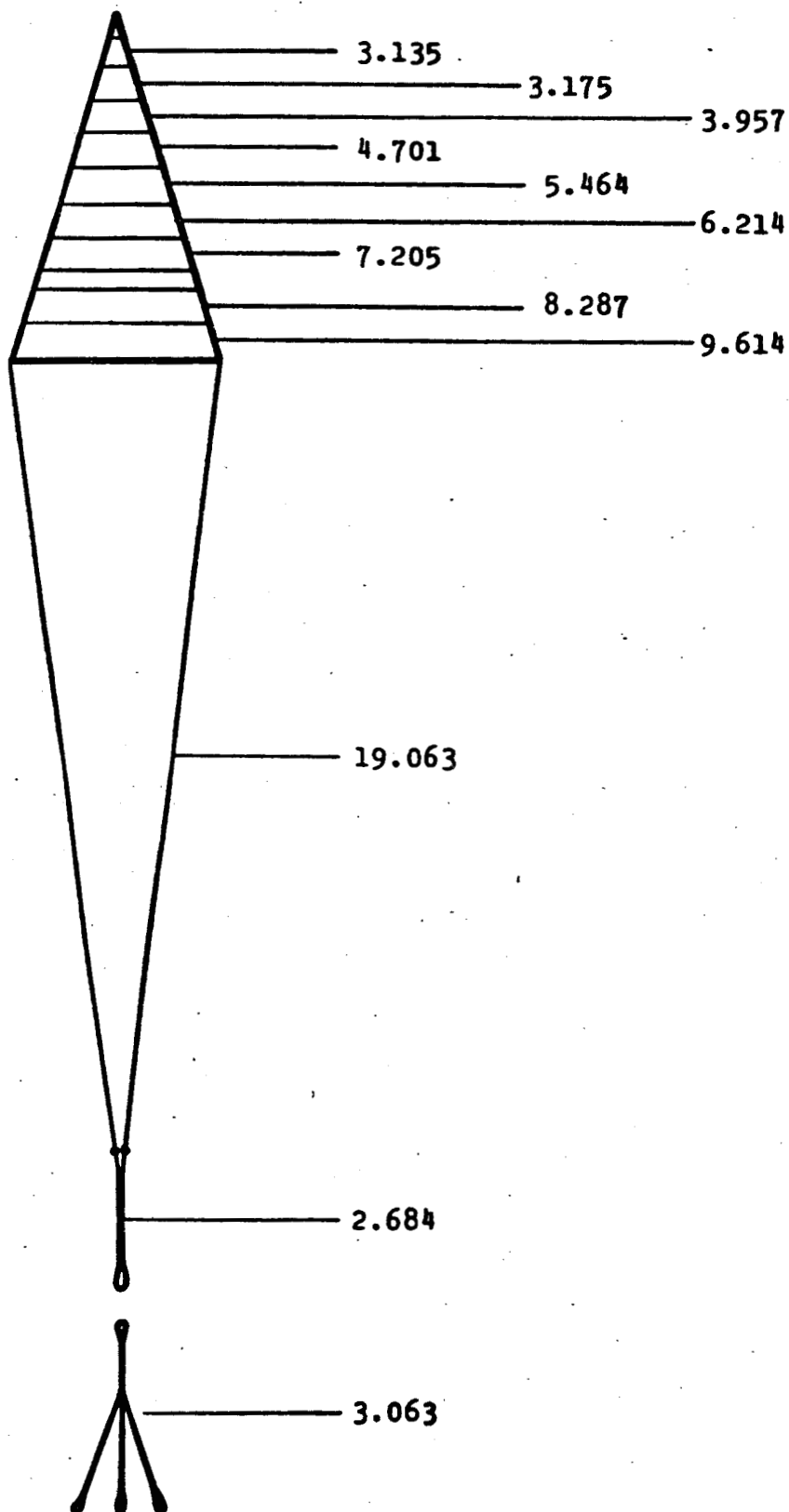
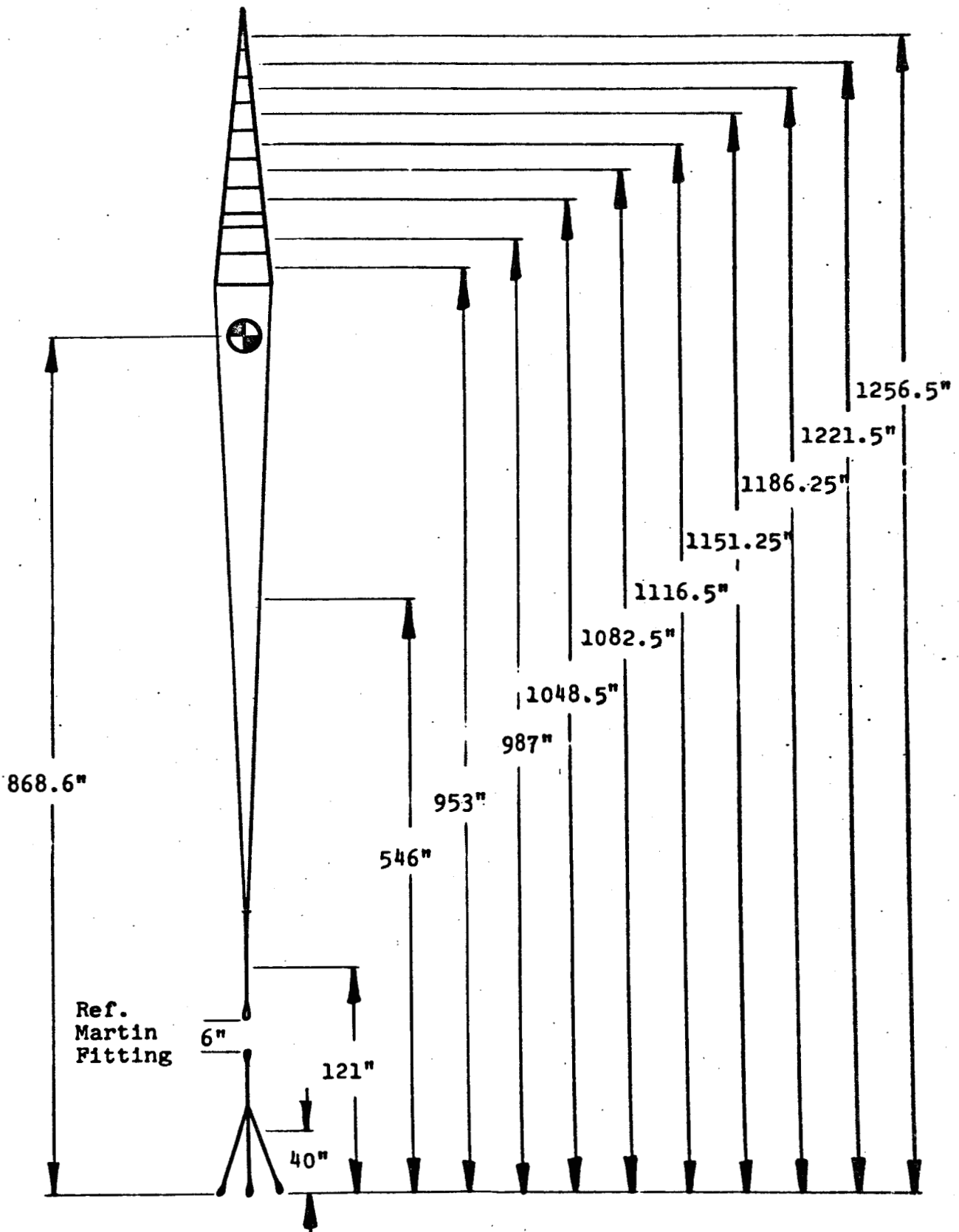


Figure 10-2. Location of Weights for "Strung-out" Parachute



Calculation of Center-of-Gravity
for "Strung-out" Parachute

Lengths taken from Fig. 10-2

Weights taken from Fig. 10-1

TABLE 10-1

Length (<i>l</i>) in.	Weight (<i>w</i>) lb	(<i>l</i>) x (<i>w</i>) = (<i>m</i>) in-lb
40.0	3.063	122.52
121.0	2.684	324.76
546.0	19.063	10408.40
953.0	9.614	9162.14
987.0	8.287	8179.27
1048.5	7.205	7554.44
1082.5	6.214	6726.66
1116.5	5.464	6100.56
1151.25	4.701	5412.03
1186.25	3.957	4693.99
1221.5	3.175	3878.26
1256.5	3.135	3939.13

$$\Sigma(w) = 76.562 \text{ lb}$$

$$\Sigma(m) = 66502.16 \text{ in-lb}$$

$$\frac{\Sigma(m)}{\Sigma(w)} = 868.6 \text{ in.}$$

Center-of-gravity is
at 868.6 in. (marked on
Fig. 10-2.)

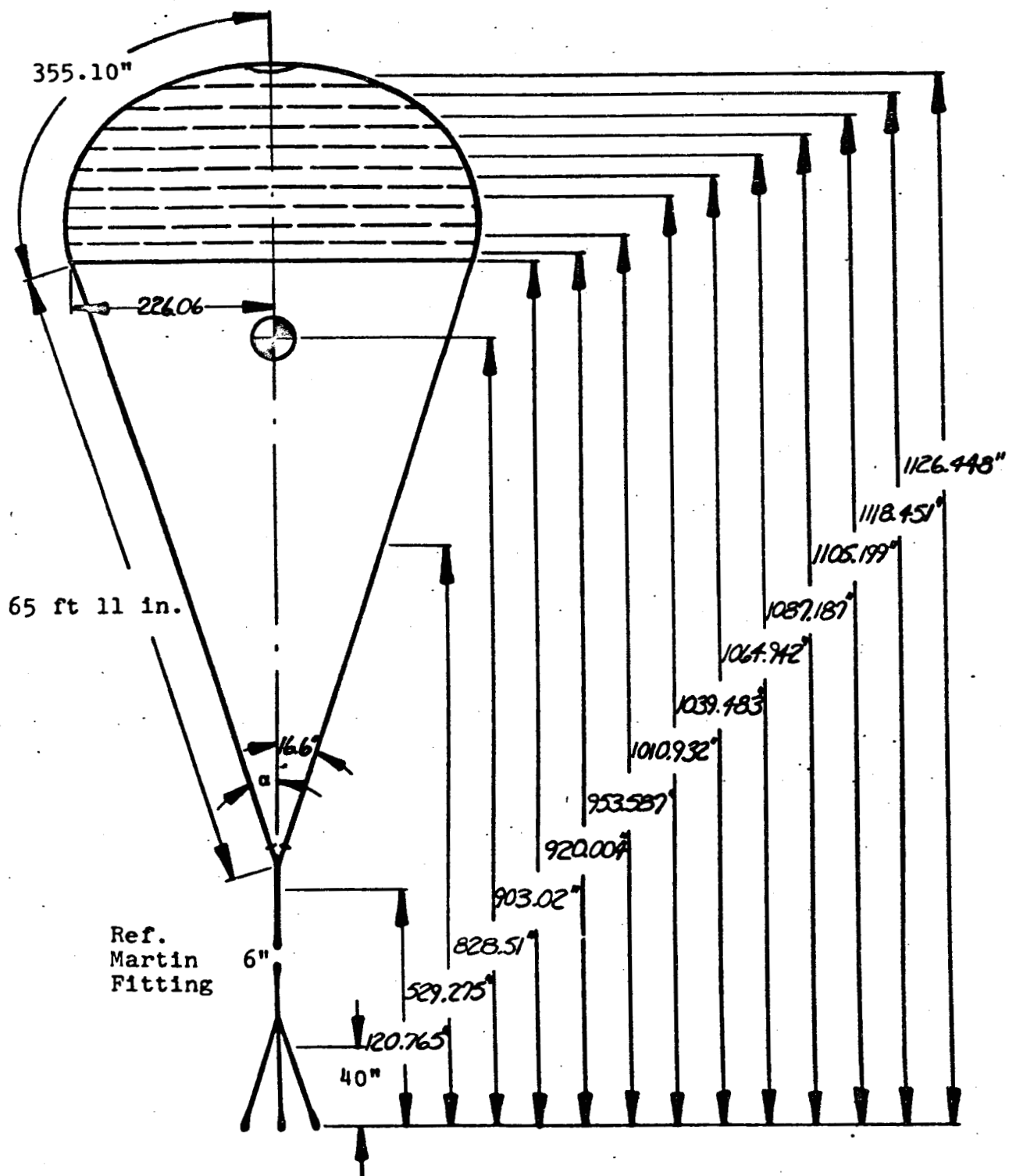


Fig. 10-3. Location of weights for inflated parachute.

Calculation of Center-of-Gravity
for Inflated Parachute

Lengths taken from Fig. 10-3

Weights taken from Fig. 10-1

TABLE 10-2

Length (<i>l</i>) in.	Weight (<i>w</i>) lb	(<i>l</i>) x (<i>w</i>) = (<i>m</i>) in-lb
40.0	3.063	122.52
120.765	2.684	324.13
529.275	19.063	10089.57
920.004	9.614	8844.92
953.587	8.287	7902.38
1010.932	7.205	7283.77
1039.483	6.214	6459.35
1064.942	5.464	5818.84
1087.187	4.701	5110.87
1105.199	3.957	4373.27
1118.451	3.175	3551.08
1126.448	3.135	3531.41
987.79	0.125	123.47*

$$\Sigma(w) = 76.687 \text{ lb}$$

$$\Sigma(m) = 63535.58 \text{ in-lb}$$

$$\frac{\Sigma(m)}{\Sigma(w)} = \underline{828.51 \text{ in.}}$$

Center of gravity is
at 828.11 in. (marked on
Figs. 10-3 and 11-1).

*Included air mass.

APPENDIX A
COMPUTER RUNS

PT. DIAMETER RINGSAIL PARACHUTE.												
CDAS	CD	INF. TIME	QSUBO	ID.								
2000-2	0.62	0.5 SEC.	12 PSF									
TIME SAIL.	CL1	CD1	CL2	CD2	CL3	CD3	CL4	CD4	TL	TD	WEIGHT	PRINT INT.
.00	.00	1.50	.00	.00	.00	.00	.00	.00	.00	.00	675.00	.05
.05	.00	1.50	.00	12.00	.00	.00	.00	.00	.00	.00	675.00	.05
.10	.00	1.50	.00	40.00	.00	.00	.00	.00	.00	.00	675.00	.05
.15	.00	1.50	.00	87.00	.00	.00	.00	.00	.00	.00	675.00	.05
.20	.00	1.50	.00	160.00	.00	.00	.00	.00	.00	.00	675.00	.05
.25	.00	1.50	.00	300.00	.00	.00	.00	.00	.00	.00	675.00	.05
.30	.00	1.50	.00	550.00	.00	.00	.00	.00	.00	.00	675.00	.05
.35	.00	1.50	.00	930.00	.00	.00	.00	.00	.00	.00	675.00	.05
.40	.00	1.50	.00	1315.00	.00	.00	.00	.00	.00	.00	675.00	.05
.45	.00	1.50	.00	1690.00	.00	.00	.00	.00	.00	.00	675.00	.05
.50	.00	1.50	.00	2060.00	.00	.00	.00	.00	.00	.00	675.00	.05
1.00	.00	1.50	.00	2060.00	.00	.00	.00	.00	.00	.00	675.00	.05
MACH NO.	CLM1	CDM1	CLM2	CDM2	CLM3	CDM3	CLM4	CDM4				
.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00				
10.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00				
Y0=	.00 SEC.	S1=	1.00 SQ. FT.	INTEGRATION INT.= .05								
R0=	.00 FT.	S2=	1.00 SQ. FT.									
V0=	1665.00 FT./SEC.	S3=	1.00 SQ. FT.									
H0=	128000.00 FT.	S4=	1.00 SQ. FT.									
GAUZE	60.00 DEG.	H5=	.00 FT.									
		TS=	1.00 SEC.									
TIME	VELOCITY	ACCELERATION	ALTITUDE	RATE OF CLIMB	DYNAMIC PRESSURE	PATH ANGLE	MACH NO.	RANGE	L2	L3	L4	
.0	1665.00	-28.75	128000.00	1441.77	12.30	59.99	1.58	.00	.0	.0	.0	.0
.0	1663.56	-35.78	128072.09	1440.12	12.32	59.96	1.57	41.64	107.8	.0	.0	.0
.1	1661.77	-52.08	128144.09	1438.17	12.25	59.93	1.57	83.27	490.1	.0	.0	.0
.1	1659.17	-79.20	128216.00	1435.51	12.18	59.91	1.57	124.86	1059.3	.0	.0	.0
.2	1655.22	-120.82	128287.70	1431.69	12.08	59.88	1.57	166.40	1932.9	.0	.0	.0
.3	1639.26	-337.37	128430.66	1417.08	11.78	59.85	1.56	207.82	3586.7	.0	.0	.0
.3	1622.55	-538.47	128501.52	1402.23	11.50	59.82	1.55	249.02	6476.6	.0	.0	.0
.4	1596.05	-724.03	128571.63	1378.92	11.10	59.76	1.53	289.84	10696.4	.0	.0	.0
.4	1560.62	-880.52	128640.57	1347.90	10.58	59.73	1.48	330.02	14590.0	.0	.0	.0
.5	1517.76	-1007.88	128707.97	1310.48	9.97	59.70	1.43	369.35	17873.9	.0	.0	.0
.5	1468.95	-943.24	128773.49	1267.92	9.32	59.67	1.39	407.63	20546.9	.0	.0	.0
.6	1423.21	-884.75	128836.89	1228.04	8.72	59.64	1.35	444.72	19191.8	.0	.0	.0
.6	1380.26	-831.67	128898.29	1190.50	8.18	59.61	1.30	480.68	17966.0	.0	.0	.0
.7	1339.86	-783.33	128957.82	1155.32	7.69	59.57	1.27	515.60	16853.3	.0	.0	.0
.7	1301.77	-739.19	129015.58	1122.07	7.24	59.54	1.23	549.52	15840.2	.0	.0	.0
.8	1265.79	-698.77	129071.69	1090.65	6.83	59.50	1.20	582.52	14915.1	.0	.0	.0
.8	1231.75	-661.66	129126.22	1060.92	6.45	59.46	1.16	614.64	14067.9	.0	.0	.0
.9	1199.50	-627.51	129179.26	1032.73	6.10	59.43	1.13	645.93	13290.2	.0	.0	.0
.9	1168.89	-596.01	129230.90	1005.96	5.78	59.39	1.10	676.44	12574.5	.0	.0	.0
1.0	1139.79	-568.05	129281.20	980.51	5.49	59.35	1.08	706.20	11914.3	.0	.0	.0
								735.26	11304.0	.0	.0	.0

E-0082. DIAMETER RINGSAIL PARACHUTE												
60-FT. INF. TIME GSUBO ID.												
RUN NO CD=5 2027/SQ.FT. 0.62 0.5 SEC. 13 PSF												
5019-2												
TIME SEL.	CL1	CD1	CL2	CD2	CL3	CD3	CL4	CD4	TL	TD	WEIGHT	PRINT IN
.00	.00	1.50	.00	.00	.00	.00	.00	.00	.00	.00	675.00	.05
.05	.00	1.50	.00	12.00	.00	.00	.00	.00	.00	.00	675.00	.05
.10	.00	1.50	.00	40.00	.00	.00	.00	.00	.00	.00	675.00	.05
.15	.00	1.50	.00	87.00	.00	.00	.00	.00	.00	.00	675.00	.05
.20	.00	1.50	.00	160.00	.00	.00	.00	.00	.00	.00	675.00	.05
.25	.00	1.50	.00	300.00	.00	.00	.00	.00	.00	.00	675.00	.05
.30	.00	1.50	.00	540.00	.00	.00	.00	.00	.00	.00	675.00	.05
.35	.00	1.50	.00	845.00	.00	.00	.00	.00	.00	.00	675.00	.05
.40	.00	1.50	.00	1145.00	.00	.00	.00	.00	.00	.00	675.00	.05
.45	.00	1.50	.00	1450.00	.00	.00	.00	.00	.00	.00	675.00	.05
.50	.00	1.50	.00	1753.00	.00	.00	.00	.00	.00	.00	675.00	.05
1.00	.00	1.50	.00	1753.00	.00	.00	.00	.00	.00	.00	675.00	.05

MACH NO.	CLM1	CDM1	CLM2	CDM2	CLM3	CDM3	CLM4	CDM4	CLM5	CDM5
.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
T0=	.00 SEC.	S1=	1.00 SQ. FT.							
R0=	.00 FT.	S2=	1.00 SQ. FT.							
V0=	1706.00 FT./SEC.	S3=	1.00 SQ. FT.							
H0=	128000.00 FT.	S4=	1.00 SQ. FT.							
GAM0=	60.00 DEG.	HS=	.00 FT.							
		TSE	1.00 SEC.							
INTEGRATION INT.= .05										

TIME	VELOCITY	ACCELERATION	ALTITUDE	RATE OF CLIMB	DYNAMIC PRESSURE	PATH ANGLE	MACH NO.	RANGE	L2	L3	L4
.0	1706.00	-28.79	128000.00	1477.27	12.99	59.99	1.61	.00	.00	.00	.00
.0	1704.56	-36.17	128073.86	1475.62	12.93	59.96	1.61	42.66	155.2	132.0	.00
.1	1702.75	-53.29	128147.64	1473.65	12.86	59.93	1.61	85.32	514.5	439.0	.00
.1	1700.09	-81.75	128221.33	1470.95	12.78	59.91	1.61	127.94	1112.0	448.0	.00
.2	1696.01	-125.44	128294.87	1467.01	12.68	59.88	1.60	170.49	2028.7	1750.0	.00
.2	1689.76	-208.12	128368.22	1461.20	12.55	59.85	1.60	212.92	3763.6	3200.0	.00
.3	1679.41	-346.67	128441.28	1451.84	12.35	59.83	1.59	255.13	6671.0	5687.0	.00
.3	1652.23	-514.59	128513.87	1436.59	12.06	59.80	1.57	293.94	10194.5	8690.0	.00
.4	1636.88	-665.15	128585.70	1414.27	11.66	59.77	1.55	338.15	13353.9	11383.0	.00
.4	1604.25	-800.49	128656.42	1385.68	11.17	59.74	1.52	378.57	16194.1	13601.0	.00
.5	1565.17	-914.16	128725.70	1351.51	10.60	59.71	1.48	418.04	18579.9	15310.0	.00
.5	1520.72	-862.08	128793.28	1312.73	9.98	59.68	1.44	458.42	17402.3	14407.0	.00
.6	1478.77	-814.44	128858.91	1276.11	9.41	59.65	1.40	493.70	16409.8	13557.0	.00
.6	1432.10	-770.74	128922.72	1241.47	8.88	59.62	1.36	530.17	15574.0	12720.0	.00
.7	1401.53	-730.56	128994.79	1208.66	8.40	59.59	1.32	565.65	14732.0	12558.0	.00
.7	1365.90	-693.52	129045.22	1177.52	7.96	59.55	1.29	600.26	13953.9	11897.0	.00
.8	1332.05	-659.31	129104.10	1147.93	7.55	59.52	1.26	634.04	13239.0	.00	.00
.8	1299.85	-627.65	129161.49	1119.77	7.17	59.48	1.23	667.03	12575.4	.00	.00
.9	1269.17	-598.27	129217.48	1092.93	6.82	59.45	1.20	699.31	11900.0	.00	.00
.9	1239.91	-570.98	129272.13	1067.33	6.50	59.41	1.17	730.66	11388.0	.00	.00
1.0	1211.97	-546.76	129325.49	1042.87	6.19	59.37	1.14	761.73	10885.6	.00	.00

FOR 55 FT. D.

RESEARCH TRIANGLE CORP. INC. 180 DEGREE OF FREQUENT INVESTIGATION PROGRAM. PUNCH CARDS CONTAINING DATA. 5010-2

60-FT. DIAMETER RINGSAIL PARACHUTE												
RUN NO		CD		INZ. TIME		CD		ID				
5010-2		1753 SQ.FT.		0.62 0.5 SEC		12 PSF		61-FT. DIA.(CD=0.60)				
TIME SEL.	CL1	CD1	CL2	CD2	CL3	CD3	CL4	CD4	TL	Tn	WEIGHT	PRINT. INT.
.00	.00	1.50	.00	.00	.00	.00	.00	.00	.00	.00	675.00	.05
.05	.00	1.50	.00	12.00	.00	.00	.00	.00	.00	.00	675.00	.05
.10	.00	1.50	.00	40.00	.00	.00	.00	.00	.00	.00	675.00	.05
.15	.00	1.50	.00	87.00	.00	.00	.00	.00	.00	.00	675.00	.05
.20	.00	1.50	.00	160.00	.00	.00	.00	.00	.00	.00	675.00	.05
.25	.00	1.50	.00	300.00	.00	.00	.00	.00	.00	.00	675.00	.05
.30	.00	1.50	.00	550.00	.00	.00	.00	.00	.00	.00	675.00	.05
.35	.00	1.50	.00	845.00	.00	.00	.00	.00	.00	.00	675.00	.05
.40	.00	1.50	.00	1145.00	.00	.00	.00	.00	.00	.00	675.00	.05
.45	.00	1.50	.00	1450.00	.00	.00	.00	.00	.00	.00	675.00	.05
.50	.00	1.50	.00	1753.00	.00	.00	.00	.00	.00	.00	675.00	.05
1.00	.00	1.50	.00	1753.00	.00	.00	.00	.00	.00	.00	675.00	.05

MAC-1 NO.									
CLM1		CDM1		CLM2		CDM2		CLM3	
1.00		1.00		1.00		1.00		1.00	
1.00		1.00		1.00		1.00		1.00	

INTEGRATION INT.= .05

T0= .00 SEC.
H0= .00 FT.
V0= 1665.00 FT./SEC.
H0= 123000.00 FT.
GAM0= 60.00 DEG.
S1= 1.00 SQ. FT.
S2= 1.00 SQ. FT.
S3= 1.00 SQ. FT.
S4= 1.00 SQ. FT.
HSE .00 FT.
TSE 1.00 SEC.

TIME	VELOCITY	ACCELERATION	ALTITUDE	RATE OF CLIP	DYNAMIC PRESSURE	PATH ANGLE	MACH NO.	L2	L3	L4
.0	1665.00	-26.75	128000.00	1441.77	12.38	59.99	1.58	.00	.0	.0
.0	1663.56	-35.78	128072.09	1440.12	12.32	59.96	1.57	41.64	147.8	.0
.1	1661.77	-52.18	128144.09	1438.17	12.25	59.93	1.57	83.27	490.1	.0
.1	1659.17	-79.20	128216.00	1435.51	12.19	59.91	1.57	124.86	1059.3	.0
.2	1655.22	-120.82	128287.78	1431.69	12.08	59.88	1.57	166.40	1932.9	.0
.2	1649.19	-199.64	129359.36	1426.07	11.96	59.85	1.56	207.82	3586.7	.0
.3	1639.26	-337.37	128430.66	1417.08	11.78	59.82	1.55	249.02	6476.6	.0
.3	1622.55	-491.86	128501.52	1402.23	11.50	59.79	1.53	289.84	9718.8	.0
.4	1596.31	-635.84	128571.63	1380.87	11.13	59.76	1.51	330.08	12739.8	.0
.4	1567.11	-765.62	128640.67	1353.51	10.66	59.73	1.48	369.57	15463.4	.0
.5	1529.71	-875.09	128708.35	1320.80	10.13	59.70	1.45	408.15	17760.9	.0
.5	1487.13	-826.29	128774.39	1283.63	9.55	59.67	1.41	445.70	16738.0	.0
.6	1446.90	-781.56	128838.57	1248.50	9.01	59.64	1.37	482.26	15800.7	.0
.6	1408.81	-740.46	128900.99	1215.23	8.52	59.61	1.33	517.89	14939.4	.0
.7	1372.70	-702.61	128961.75	1183.68	8.07	59.58	1.30	552.65	14146.2	.0
.7	1338.42	-667.67	129020.94	1153.70	7.65	59.54	1.26	586.57	13414.0	.0
.8	1305.01	-635.34	129078.62	1125.19	7.27	59.51	1.23	619.71	12736.6	.0
.8	1274.77	-605.38	129134.88	1098.03	6.91	59.47	1.20	652.08	12108.8	.0
.9	1245.17	-577.55	129193.78	1072.13	6.57	59.43	1.18	683.75	11525.6	.0
.9	1216.91	-551.65	129243.39	1047.39	6.27	59.39	1.15	714.72	10983.1	.0
1.0	1189.91	-528.65	129295.76	1023.74	5.98	59.36	1.12	745.05	10477.4	.0

11.0 PARACHUTE ASSEMBLY MASS MOMENTS OF INERTIA

11.1 Parachute Assembly and Its C.G. Location

Figure 11-1 depicts the characteristics of a ringsail parachute assembly, which upon canopy inflation takes the shape of a hemisphere. Using axis A-A as a base reference the parachute assembly c.g. location can be expressed as

$$\bar{z}_{A-A} = [W_c + W_b]z_1 + W_s z_3 - W_r z_4] W_T \quad (11-1)$$

For the 55-ft D_0 ringsail, Table 11-1 lists the evaluated characteristics. Use of the above equation results in

$$\bar{z}_{A-A} = 55.85 \text{ ft} \quad (11-2)$$

The location of the system c.g. with respect to the y-y axis is therefore given by

$$\bar{z}_{y-y} = -[62.29 - 55.85] = -6.44 \text{ ft} \quad (11-3)$$

11.2 Canopy Material

11.2.1 Roll Inertia of Fabric Circumferential Bands That Make Up Canopy (with respect to z-z axis)

The roll mass moment of inertia can be shown to be

$$I_{z-z} = \sum^n [2/3 m_c r^4 \{ \sin \theta_2 (\cos^2 \theta_2 + 2) - \sin \theta_1 (\cos^2 \theta_1 + 2) \}] \quad (11-4)$$

where m_c is the canopy material mass distribution per unit area and n is the number of circumferential rings.

Table 11-2 depicts the properties associated with the circumferential rings used on the 55-ft D_0 ringsail parachute. Evaluation of equation (11-4) yields

$$I_{z-z} = 286.000 \text{ lb-ft-sec}^2 \quad (11-5)$$

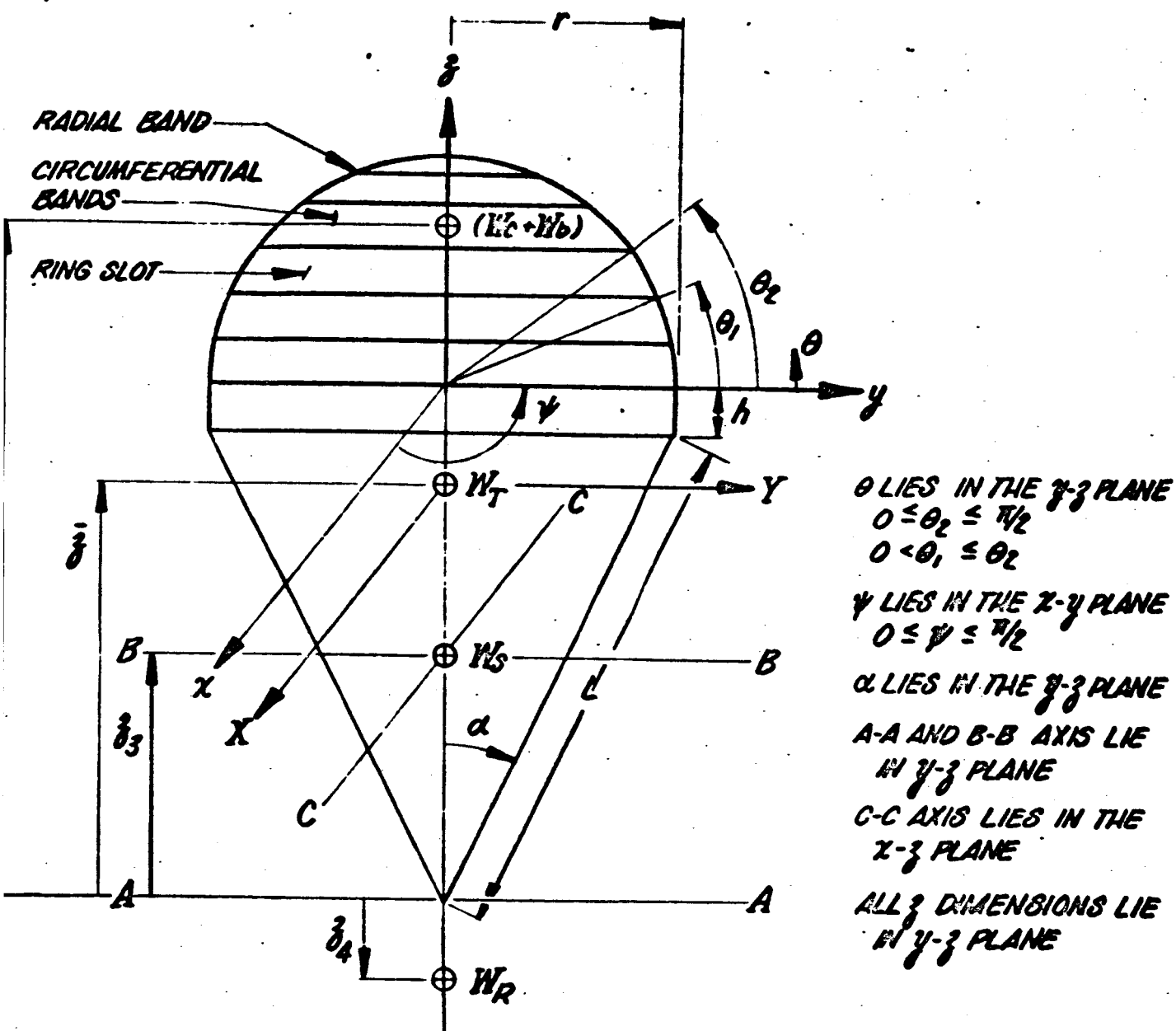


FIGURE 11-1 PARACHUTE ASSEMBLY

TABLE 11-1
Characteristics of 55-ft D₀
Ringsail Parachute Assembly.

ITEM	W (lbs)	z (ft)	Description
W_c	41.565	72.18	Canopy Material
W_b	9.212	72.18	54 Radial Bands
W_s	19.063	31.15	54 Shroud Lines
W_R	5.745	-6.48	Riser Assembly
W_T	75.585	\bar{z}	Parachute Assembly Total Weight

α , angle made between any shroud line and system centerline = 16.6°

r , canopy inflated radius = 18.838 ft

L , shroud line length = 65.9 ft

TABLE 11-2

Properties of Fabric Circumferential Rings
Associated With 55 Ft D₀ Ringsail Parachute Canopy.

RING NO.	WT. (LB)	θ_1 (deg)	θ_2 (deg)
1	1.578	76.80	85.41
2	2.152	67.80	76.42
3	2.953	58.86	67.48
4	3.707	50.00	58.61
5	4.385	41.19	49.80
6	5.135	32.57	41.19
7	6.126	23.95	32.57
8	0	---	---
9	7.117	8.36	16.96
10	8.412	0	8.36

Total 41.565 lb

Total area of 10 circumferential rings
(total canopy cloth area) = 1990 ft²

$$m_c = \frac{41.565}{32.2 (1990)} = .649 \times 10^{-3} \text{ lb-sec}^2/\text{ft}^3$$

11.2.2 Pitch and Yaw Inertia of Fabric Bands That Make Up Canopy (with respect to x-x and y-y axis).

The pitch and yaw mass moment of inertia can be shown to be

$$I_{x-x} = I_{y-y} = \sum^n [m_c r^4 \{ \frac{\sin \theta_2}{3} (\cos^2 \theta_2 + 2) - \frac{\sin \theta_1}{3} (\cos^2 \theta_1 + 2) \} + \frac{2}{3} \{ \sin^3 \theta_2 - \sin^3 \theta_1 \}] \quad (11-6)$$

For the 55-ft D₀ ringsail parachute

$$I_{x-x} = I_{y-y} = 144.894 \text{ lb-ft-sec}^2 \quad (11-7)$$

With respect to the parachute assembly c.g. axis

$$I_{X-X} = I_{Y-Y} = 144.894 + \frac{41.565}{32.2} (6.44)^2 = 198.430 \text{ lb-ft-sec}^2 \quad (11-8)$$

11.3 Radial Bands

11.3.1 Roll Inertia of Radial Bands on a Canopy (with respect to z-z axis).

The roll mass moment of inertia of the radial bands can be shown to be

$$I_{z-z} = n m_b r^3 \{ \frac{\theta_2 - \theta_1}{2} + \frac{\sin 2\theta_2 - \sin 2\theta_1}{4} \} \quad (11-9)$$

where n is the number of radial bands under consideration. The mass distribution, m_b, is the mass of the radial band per unit running length. Hence

$$m_b = \frac{W_b}{n g r \frac{\pi}{2}} \quad (11-10)$$

For the 55 ft D₀ ringsail parachute under consideration herein there are 54 radial bands. Hence

$$m_b = \frac{2 (9.212)}{54 (32.2) (18.838) (3.14)} = .179 \times 10^{-3} \frac{\text{lb sec}^2}{\text{ft}^2} \quad (11-11)$$

Equation (11-9) when used for the 55 ft D_0 ringsail yields

$$I_{z-z} = 50.751 \text{ lb-ft-sec}^2 \quad (11-12)$$

11.3.2 Pitch and Yaw Inertia of Radial Bands on a Canopy

(with respect to x-x and y-y axis).

The pitch and yaw mass moment of inertia can be shown to be

$$I_{x-x} = I_{y-y} = 2 \sum_{p=1}^P m_b r^3 \left[\sin^2 \gamma \left\{ \frac{\theta_2 - \theta_1}{2} + \frac{\sin 2\theta_2 - \sin 2\theta_1}{4} \right\} + \frac{\theta_2 - \theta_1}{2} - \frac{\sin 2\theta_2 - \sin 2\theta_1}{4} \right] \quad (11-13)$$

where, for the following,

p	γ	p	γ
1	0°	15	93°20'
2	6°40'	16	100°
3	13°20'	17	106°40'
4	20°	18	113°20'
5	26°40'	19	120°
6	33°20'	20	126°40'
7	40°	21	133°20'
8	46°40'	22	140°
9	53°20'	23	146°40'
10	60°	24	153°20'
11	66°40'	25	160°
12	73°20'	26	166°40'
13	80°	27	173°20'
14	86°40'		

In the 55 ft D_0 ringsail parachute

$$I_{x-x} = I_{y-y} = 76.126 \text{ lb-ft-sec}^2$$

The pitch and yaw mass moment of inertia with respect to the system's c.g. is

$$I_{X-X} = I_{Y-Y} = 76.126 + \frac{9.212}{32.2} (6.44)^2 = 87.991 \text{ lb-ft-sec}^2 \quad (11-14)$$

11.4 Shroud Lines

11.4.1 Roll Inertia of Shroud Lines Making Up a Parachute
(with respect to z-z axis).

The roll mass moment of inertia of a number of shroud lines can be shown to be

$$I_{z-z} = n \frac{m_s L^3}{3} \sin^2 \alpha \quad (11-15)$$

where m_s is the mass distribution of the shroud line per running unit length. The number of shroud lines is designated n .

$$m_s = \frac{W_s}{n L g} \quad (11-16)$$

In the 55 ft D_0 ringsail

$$m_s = \frac{19.063}{54(65.9)32.2} = .168 \times 10^{-3} \frac{\text{lb sec}^2}{\text{ft}^2} \quad (11-17)$$

Using equation (11-15) yields

$$I_{z-z} = 70.636 \text{ lb-ft-sec}^2 \quad (11-18)$$

11.4.2 Pitch and Yaw Inertia of Shroud Lines Making Up a Parachute (with respect to B-B and C-C axis).

The pitch and yaw inertia can be shown to be

$$I_{B-B} = I_{C-C} = 4 \frac{p}{\pi} [m_s L^3 \sqrt{\frac{\sin^2 \alpha \sin^2 \gamma + \cos^2 \alpha}{1 - \sin^2 \alpha \cos^2 \gamma}} \{ \frac{\sin^2 \alpha \sin^2 \gamma}{3} + \frac{7}{12} \cos^2 \alpha - \frac{\cos \alpha}{2} \}] \quad (11-19)$$

(NOTE: For this case $\sqrt{\frac{\sin^2 \alpha \sin^2 \gamma + \cos^2 \alpha}{1 - \sin^2 \alpha \cos^2 \gamma}} = 1$).

Using equation (11-19) yields

$$I_{B-B} = I_{C-C} = 89.641 \text{ lb-ft-sec}^2 \quad (11-20)$$

With respect to the system's c.g.

$$I_{X-X} = I_{Y-Y} = 89.641 + \frac{19.063}{32.2}(24.7)^2 = 450.825 \text{ lb-ft-sec}^2 \quad (11-21)$$

TABLE 11-3
Summary

Member	I_{z-z} (lb-ft-sec ²)	$I_{x-x} = I_{y-y}$ (lb-ft-sec ²)
Canopy rings	286.000	198.430
Radial bands	50.751	87.991
Shroud lines	70.636	450.825

12.0 FABRICATION AND PACKING

12.1 Fabrication

The parachute-fabrication sequence was as follows.

- (a) Cut cloth and stamp ring or sail number in upper-righthand corner.
- (b) Baste rings or sails together down main seams, forming a series of complete rings from vent to skirt.
- (c) Attach circumferential reinforcing tapes to leading and trailing edges of rings and sails.
- (d) Make skirt and vent hems.
- (e) Sew cotton loop buffer to radial tapes, folding the radial, ready for suspension-line-attachment loop formation.
- (f) Attach radial tapes, starting at the vent, matching marks to ring and sail edges. Insert the radial-gap-reinforcement tape through the gap and form the suspension-line-attachment loop when the skirt is reached.
- (g) Attach vent lines to radials at vent with zig-zag stitch pattern.
- (h) Add zig-zag stitching to radial at skirt, top and bottom of the gap, and through the slots between rings 1, 2, and 3.
- (i) Attach suspension lines to suspension-line-attachment loops and zig-zag stitch.
- (j) Fabricate the attached riser per Pioneer Dwg. 3.73454 and attach the six ends to the links using a four-point cross-stitch pattern.

12.2 PACKING PROCEDURE FOR 55-FT RINGSAIL ASSY. #19.1466
REV. ORIG

1. Check and record part number, serial number, and weight of canopy, deployment bag, and riser. (Use Form E-0082-AT/3.)
2. Verify that Pioneer and Martin inspection stamps are on canopy, on bag flap, and adjacent to assy S/N on bag.
3. Stretch canopy and suspension lines under tension.
4. Pleat canopy gores, 27 to each side, with #1 gore up.
5. Install 6-cord Dacron tie (approx. 6 ft long) to loop in bottom inside of bag. (Use bowline knot.)
6. Attach 6-cord Dacron tie through sleeve from bag to apex. (Use bowline knot.)
7. Relieve tension.
8. Place dummy riser in deployment bag riser flap. Place bag in packing container, and secure with cord.
9. Fold panels #1 through #7 into bag and put under pressure.
10. Relieve pressure, fold in panel #9, and reapply pressure.
11. Relieve pressure, fold in panel #10, and reapply pressure.
12. Relieve pressure.
13. Gather suspension lines into bundles approximately 10 in. long and hold with rubber bands.
14. Lay in one level of bundled suspension lines. Remove rubber bands from laid-in level.
15. Lay in next level of bundled suspension lines at right angles to previous level. Remove rubber bands from laid-in level.

16. Continue to lay in bundles of suspension lines until all lines are stowed.

17. Reapply pressure.

18. Fold in riser portion of canopy to cutter knife, and tie bag mouth with 550-lb Nylon cord sleeve, and attach red flag. (Use slip knot with locking loop.)

19. Feed 300-lb Dacron cord through mouth ties, and rig cutter knife.

20. Fold in excess riser.

21. Install lid and retaining bolts.

APPENDIX B
JOINT-TEST REPORTS

LABORATORY JOINT-TEST REPORTS

This appendix presents the results of laboratory strength-of-materials and structural-integrity tests required by Para. 1.15c of the Work Statement of Martin Marietta Procurement Specification No. LY 152450, Rev. E, for Contract RC7-709039.

The tests reported on were made to ascertain the adequacy of the primary structural members of the parachute assembly, Pioneer Dwg. 19.1466. The style and format of these reports are in accordance with parachute-industry standard technology.

Figure 1 and Table 1 are furnished as a guide to locating specific tests. Test reports follow Table 1 in numerical order. If an illustration accompanies a report, it bears the same identifying number as the report.

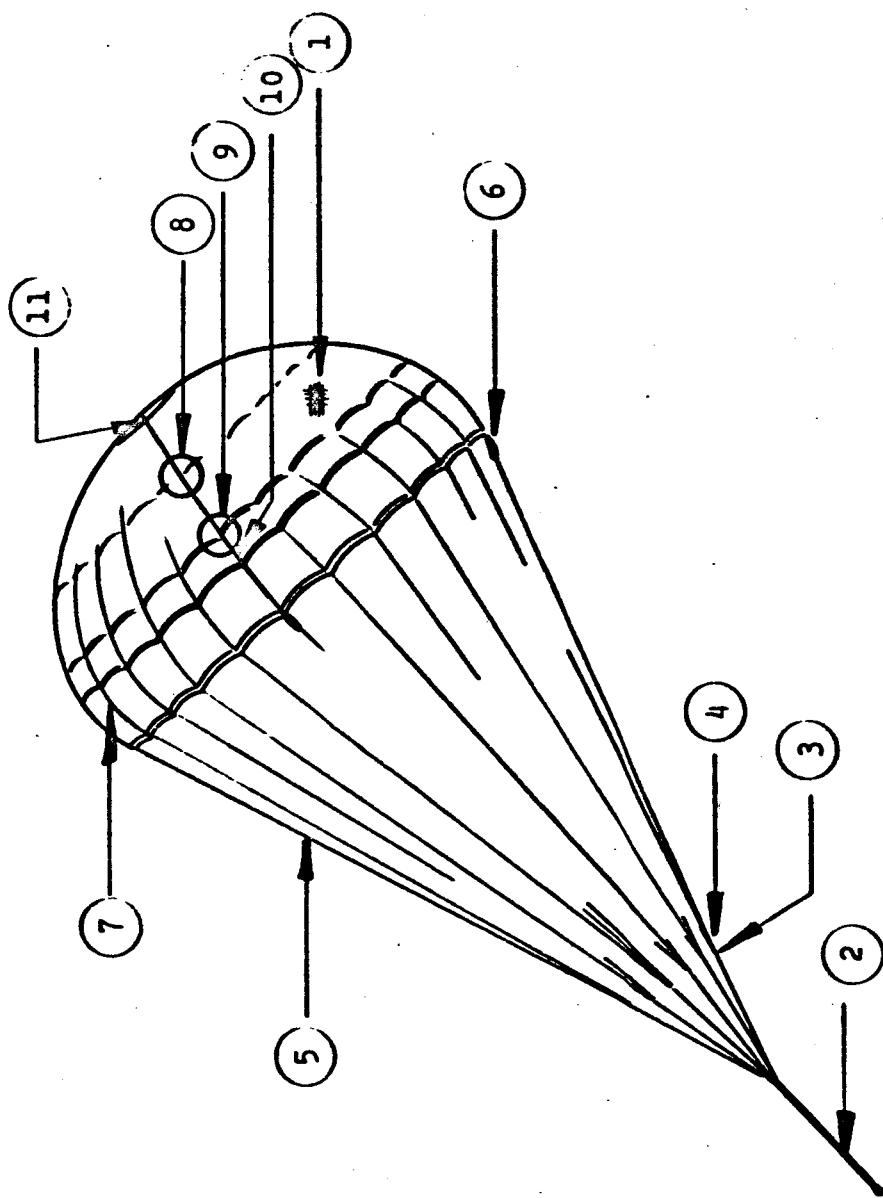


Figure 1. Key to laboratory-test reports, E-0082-TL series, for ringsail parachute 1.5438.

TABLE 1
LABORATORY TEST REPORTS, E-0082-TL SERIES

Test no. E-0082-TL/	Item(s) tested
1	Cloth, Dacron, heat stabilized per Pioneer Spec. E-0082-2
2	Webbing, Dacron, 1-3/4 x 7000 lb per Spec. MIL-W-25361, Type III
3	Joint, webbing to link
4	Joint, suspension line to link
5	Cord, coreless, Dacron, 16 x 16 per Pioneer Spec. E-0067-2 or E-0082-3
6	Joint, suspension line to loop
7	Tape, Dacron, 3/4 x 550 lb
8	Joint, radial to circumferential tape through slot
9	Joint, radial to circumferential tape through gap section
10	Radial tape through gap area
11	Joint, vent line to radial tape

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Cloth, Dacron, heat stabilized, Per Pioneer Spec. E-0082-2		PROJECT NO. E-0082	
		TEST NO. E-0082-TL/1	
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input type="checkbox"/> POINT OF FAILURE <input type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER			
TEST METHOD Use Scott tester Model J3, with 12-in./min. load rate, and 3-in. test sample, warp direction only, unless otherwise specified from Engineering verification tests.			
REQUESTED BY JPB	DATE REQUESTED 8/3/67	REQUEST APPD. BY JPB	DATE APPROVED 8/3/67

TABLE					
Sample no.	Ult. t.s., lb	No. of ends	Sample no.	Ult. t.s., lb	No. of ends
1	86	115	9	85	116
2	86	116	10	84	115
3	86	116	11	84½	115
4	85½	115	12	84	116
5	85½	115	13	85½	116
6	87	117	14	84½	116
7	85½	115	15	79½	113
8	84½	115	16	83½	115

From Receiving Inspection Test

Sample no.	Ult. t.s. lb
1	69
2	70
3	63
4	68

COMMENTS Check of strength of 6 pieces of warp thread = 0.7 lb each. Accuracy of machine = ± 0.1 lb. Scott Model X-5 load rate = 12"/min. Length of sample (between jaws) = 10 in.

RESULTS From 16 engineering verification tests.

Min. ult. t.s. = 79½ lb
Max. ult. t.s. = 87 lb
Av. ult. t.s. = 84.8 lb

$\Delta = 7½$ lb

From 4 receiving inspection tests.

Min. ult. t.s. = 63 lb
Max. ult. t.s. = 70 lb
av. ult. t.s. = 67.5 lb

$\Delta = 7$ lb

CONCLUSIONS Pioneer test results (these performed for engineer verification) are very similar to test results obtained from Finisher and U.S. Testing Labs.

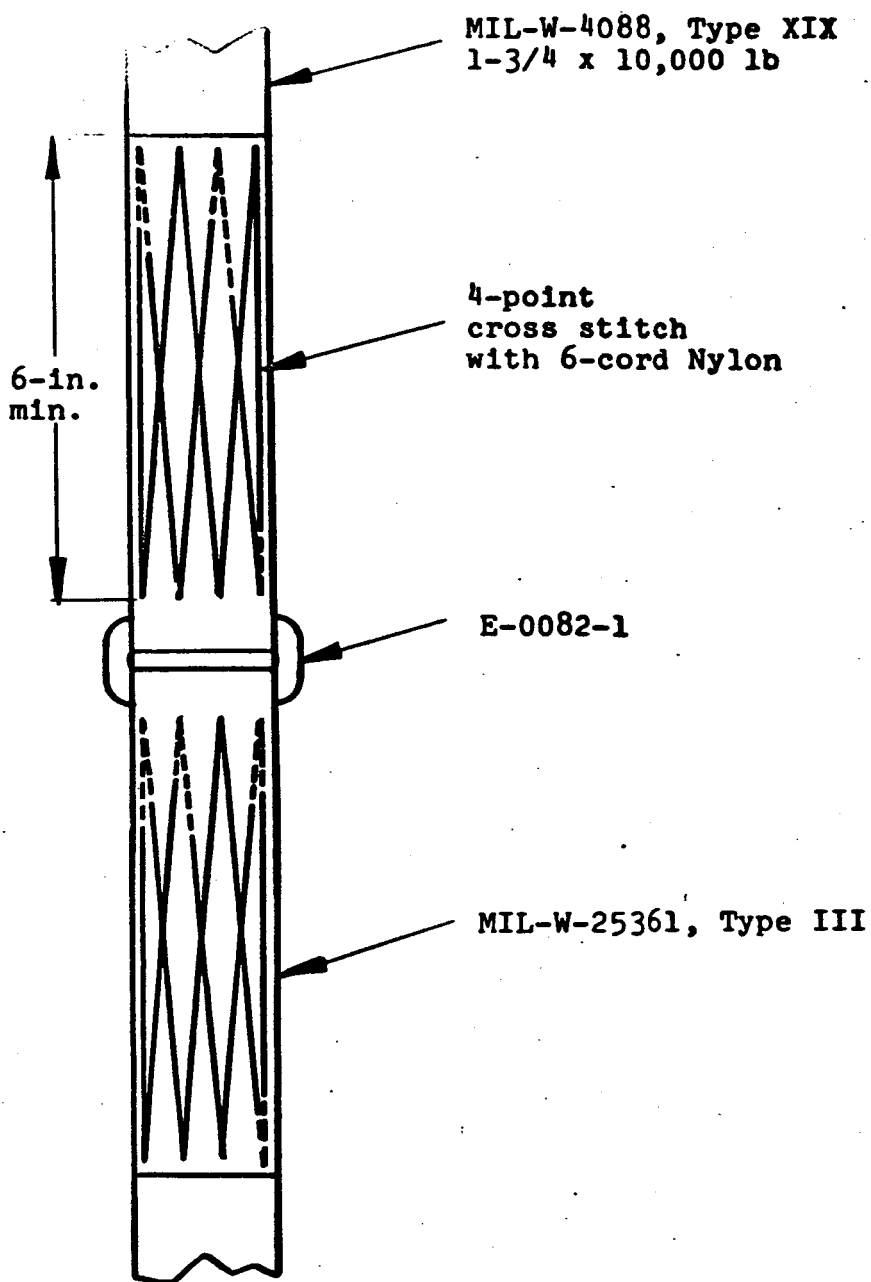
TESTED BY T. Bayles & F. Stone DATE COMPLETED 8/7/67

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Webbing, Dacron 1-3/4 x 7000 lb, per Spec MIL-W-25361, Ty. III (recap. of test results).		PROJECT NO. E-0082											
		TEST NO. E-0082-TL/2											
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input type="checkbox"/> POINT OF FAILURE <input type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER													
TEST METHOD Use Tinius Olsen Tension-testing machine, 12,000-lb range and 3 1/2-in. split drums. Load rate 12-in./min.													
REQUESTED BY JPB	DATE REQUESTED 3/6/67	REQUEST APPD. BY JPB	DATE APPROVED 3/6/67										
<table border="1"> <thead> <tr> <th>Sample</th> <th>Ult. t.s., lb</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>8725</td> </tr> <tr> <td>2</td> <td>8725</td> </tr> <tr> <td>3</td> <td>8720</td> </tr> <tr> <td>Av</td> <td>8723</td> </tr> </tbody> </table>		Sample	Ult. t.s., lb	1	8725	2	8725	3	8720	Av	8723	COMMENTS Webbing bought on P.O. 41529. Vendor certification for ult. t.s. based on av. of 5 samples = 8876 lb. Low break = 8720 lb.	
Sample	Ult. t.s., lb												
1	8725												
2	8725												
3	8720												
Av	8723												
RESULTS See table.													
CONCLUSIONS Webbing is in excess of rated t.s. of mat'l; therefore, webbing is acceptable for use intended.													
TESTED BY LaRiviere		DATE COMPLETED August 1, 1967											

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Joint, webbing to link ref. Detail "F" Dwg. 1.5438		PROJECT E-0082 NO.															
		TEST NO. E-0082-TL/3															
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input checked="" type="checkbox"/> POINT OF FAILURE <input type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER																	
TEST METHOD Use Tinius Olsen tension-testing machine, 12.0 K range and 3½-in. split drums, load rate 12-in./min. (See attached sketch for detail of test sample.)																	
REQUESTED BY JPB	DATE REQUESTED 14 July 67	REQUEST APPD. BY JPB	DATE APPROVED 14 July 67														
<table border="1"> <thead> <tr> <th>TABLE Sample</th> <th>Ult. t.s., lb</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>6670*</td> </tr> <tr> <td>2</td> <td>6580*</td> </tr> <tr> <td>3</td> <td>6630†</td> </tr> <tr> <td>4</td> <td>6810†</td> </tr> <tr> <td>5</td> <td>6240†</td> </tr> <tr> <td>Av</td> <td>6586</td> </tr> </tbody> </table> <p>*Tested 18 July 67 by JPB. †Tested 14 July 67 by T. Bayles.</p>		TABLE Sample	Ult. t.s., lb	1	6670*	2	6580*	3	6630†	4	6810†	5	6240†	Av	6586	<p>COMMENTS</p> <p>For webbing, Pioneer Receiving Inspection reports show:</p> <p>Min ult. t.s. = 8720 lb Av ult. t.s. = 8723 lb Max ult. t.s. = 8725 lb</p>	
TABLE Sample	Ult. t.s., lb																
1	6670*																
2	6580*																
3	6630†																
4	6810†																
5	6240†																
Av	6586																
<p>RESULTS</p> <p>Av ult. t.s. = 6586 lb Min ult. t.s. = 6240 lb Max ult. t.s. = 6810 lb</p> <p>Eff. =(Min ult. t.s. joint)/(Min ult. t.s. mat'l) = 6240/8720 = 71.56%.</p> <p>Eff. =(Av ult. t.s. joint)/(Av ult. t.s. mat'l) = 6586/8723 = 75.50%.</p>																	
CONCLUSIONS Joint is acceptable for intended use.																	
TESTED BY Brecht & Bayles		DATE COMPLETED July 26, 1967															

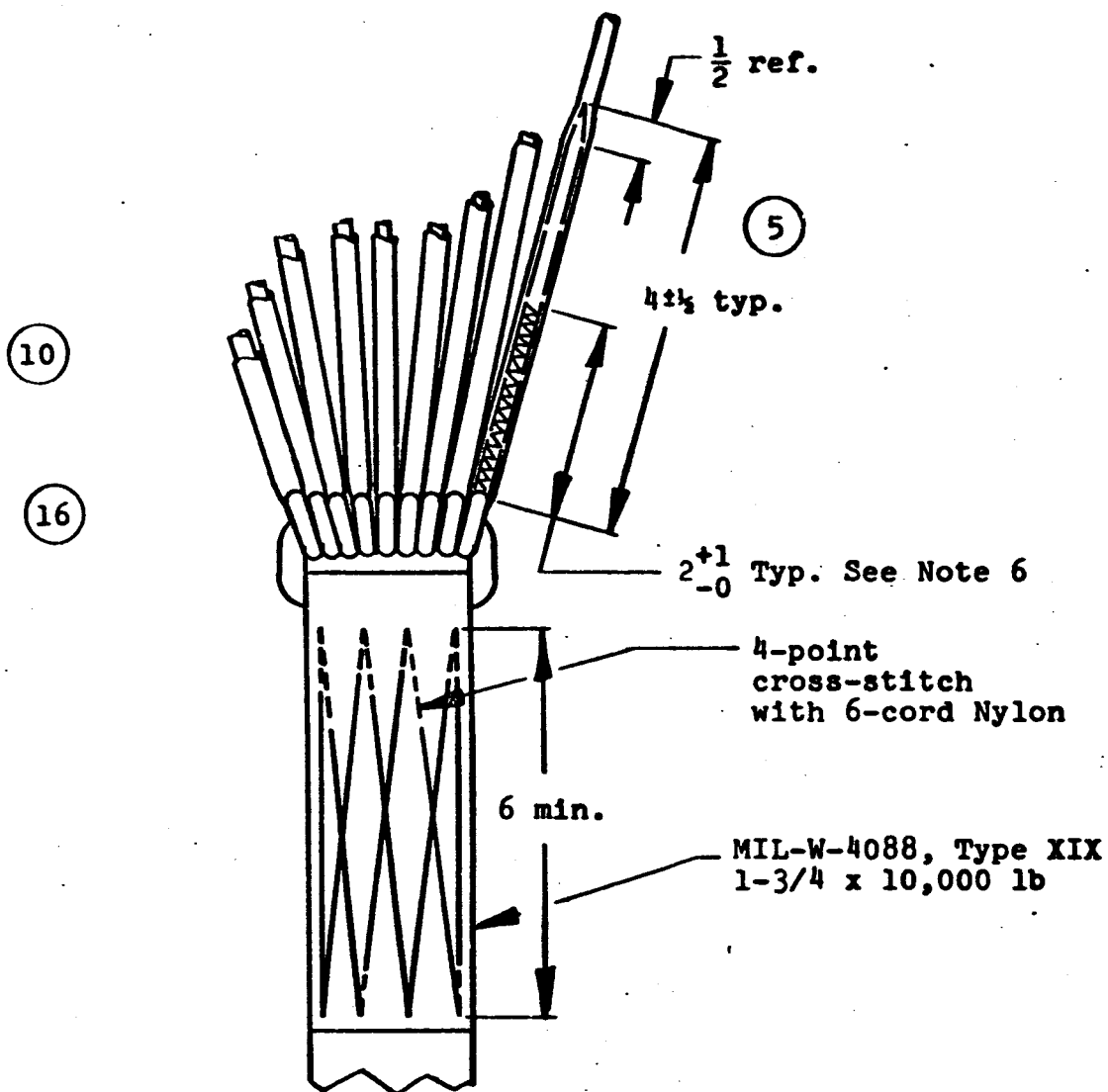


For construction details ref. Detail "F" Dwg. 1.5438

Joint, Webbing to Link
Sketch E-0082-TL/3

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Joint, suspension line to link. 55-ft Ringsail Parachute Ref Dwg. 1.5438		PROJECT NO. E-0082																															
		TEST NO. E-0082-TL/4																															
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input checked="" type="checkbox"/> POINT OF FAILURE <input checked="" type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER																																	
TEST METHOD Use Tinius Olsen tension-testing machine, 2400-lb scale, w/12-in./min. load rate, 10 in. between jaws - start condition and 3½-in. split drums.																																	
REQUESTED BY JPB	DATE REQUESTED 18 July 67	REQUEST APPD. BY JPB	DATE APPROVED 18 July 67																														
<table border="1"> <thead> <tr> <th>Sample</th> <th>Ult. strength, lb</th> <th>Note</th> </tr> </thead> <tbody> <tr><td>1</td><td>622</td><td>(1)</td></tr> <tr><td>2</td><td>640</td><td>(2)</td></tr> <tr><td>3</td><td>632</td><td>(2)</td></tr> <tr><td>4</td><td>628</td><td>(1)</td></tr> <tr><td>5</td><td>646</td><td>(2)</td></tr> <tr><td>6</td><td>630</td><td>(2)</td></tr> <tr><td>7</td><td>650</td><td>(1)</td></tr> <tr><td>8</td><td>644</td><td>(1)</td></tr> <tr><td colspan="2">Av. (1) 636 (2) 637</td><td>(1&2) 636.5</td></tr> </tbody> </table>		Sample	Ult. strength, lb	Note	1	622	(1)	2	640	(2)	3	632	(2)	4	628	(1)	5	646	(2)	6	630	(2)	7	650	(1)	8	644	(1)	Av. (1) 636 (2) 637		(1&2) 636.5	<p>COMMENTS</p> <p>Weakest member of joint is cord, coreless, Dacron, E-0082-3. From recap. of test report based on 30 samples, ult. strength of cord is as follows:</p> <p>Min = 610 lb Av = 638 lb Max = 660 lb</p> <p>(1) Failed at reduced cross section. (2) Cord failed.</p>	
Sample	Ult. strength, lb	Note																															
1	622	(1)																															
2	640	(2)																															
3	632	(2)																															
4	628	(1)																															
5	646	(2)																															
6	630	(2)																															
7	650	(1)																															
8	644	(1)																															
Av. (1) 636 (2) 637		(1&2) 636.5																															
<p>RESULTS Joint efficiency is:</p> <p>(Joint t.s. min)/(min. ult. t.s. of cord) = 622/610 = 1.02 = 102%.</p> <p>(Joint t.s. av)/(av ult. t.s. of cord) = 636/638 = 0.9969 = 99.69%.</p> <p>(Joint t.s. min)/(av ult. t.s. of cord) = 622/638 = 0.9749 = 97.49%.</p> <p>(Joint t.s. min)/(max ult. t.s. of cord) = 622/660 = 0.9424 = 94.24%.</p>																																	
CONCLUSIONS Joint efficiency used in preliminary design stress report (95%) appears to be reasonable.																																	
TESTED BY Fay & Julie		DATE COMPLETED																															



For construction details ref.
Detail "F" Dwg. 1.5438

Joint, Line to Link
Sketch E-0082-TL/4

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Cord, Coreless, Dacron 16x16 per Pioneer Spec E-0067-2 or E-0082-3				PROJECT NO. E-0082			
				TEST NO. E-0082-TL/5			
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input type="checkbox"/> POINT OF FAILURE <input type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER							
TEST METHOD Pioneer Method #6 or Federal Specification CCC-T-191b, Method 4102 as noted. Use Tinius Olsen tension-testing machine on 2400-lb scale, using 3½-in. split drums.							
REQUESTED BY JPB		DATE REQUESTED April 13, 67		REQUEST APPD. BY JPB		DATE APPROVED April 13, 67	

TABLE								
Min ult. t.s., lb								
Sample	Roll 601*	Roll 602	Roll 603	Roll 604	Roll 605	Roll 606	Roll 607	Roll 608
1	620	648	650	620	652	640	624	630
2	638	610	658	640	640	640	660†	638
3	630	615	658	640	642	636	658†	630†
4	640						660†	625†
5	620						658†	630†

*Rolls 601 through 606 bought on P.O. 41513. Roll 607 bought on P.O. 42116. Roll 608 bought on P.O. 42272.

†Pioneer method #6. All others original Rec. Insp. test, using method 4102.

RESULTS Based on 30 samples of cord, test results are as follows:	
Av. ult. t.s.	= 638 lb
Min. ult. t.s.	= 610 lb
Max. ult. t.s.	= 660 lb
Δ t.s. = max - min	= 50 lb

NOTE: This report is a recapitulation of all Receiving Inspection and Engineering verification reports on this cord to date.

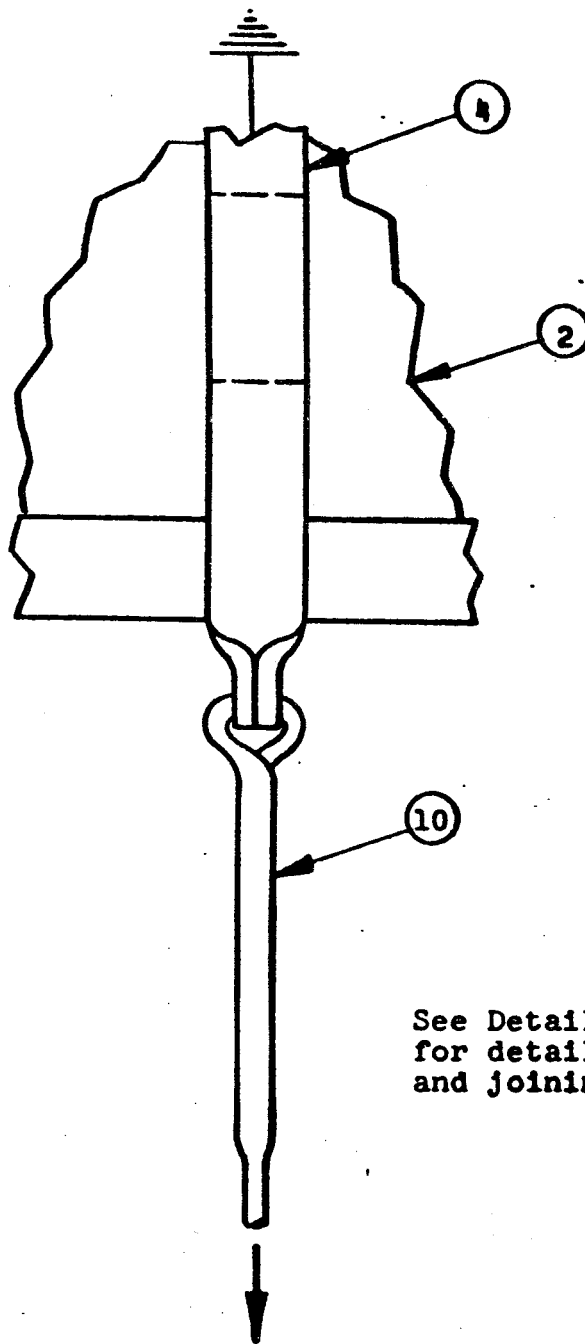
CONCLUSIONS Cord is acceptable for use intended.	
NOTE: Rate tensile strength of Spec E-0067-2 cord is 550 lb, and Spec E-0082-3 is 605 lb.	

TESTED BY Bayles, Brecht,	DATE COMPLETED 24 July 67
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Fay Stone, & LaRiviere

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Joint, suspension line to loop. 55-ft Ringsail Parachute, ref. Dwg. 1.5438.		PROJECT NO. E-0082																	
		TEST NO. E-0082-TL/6																	
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input checked="" type="checkbox"/> POINT OF FAILURE <input checked="" type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER																			
TEST METHOD Use Tinius Olsen Tension-testing machine, 2400-lb scale, w/12-in./min. load rate, 10 in. between jaws - start condition and 3½-in. split drums.																			
REQUESTED BY JPB	DATE REQUESTED 26 July 67	REQUEST APPD. BY JPB	DATE APPROVED 26 July 67																
<table border="1"> <thead> <tr> <th>TABLE</th> <th></th> </tr> <tr> <th>Sample</th> <th>Ult. t.s., lb</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>590*</td> </tr> <tr> <td>2</td> <td>600*</td> </tr> <tr> <td>3</td> <td>613*</td> </tr> <tr> <td>4</td> <td>590*</td> </tr> <tr> <td>5</td> <td>625*</td> </tr> <tr> <td>6</td> <td>640†</td> </tr> </tbody> </table> <p>*Cord failed at change of section. Av. ult. strength = 603.6 lb.</p> <p>†Cord failed at other than change of section.</p>		TABLE		Sample	Ult. t.s., lb	1	590*	2	600*	3	613*	4	590*	5	625*	6	640†	<p>COMMENTS</p> <p>Weakest member of joint is cord, coreless, Dacron per Pioneer Spec E-0082-3 (16 x 16 cord). Lowest break was 610 lb. Av. of 30 tests was 638 lb. Max. ult. t.s. was 660 lb.</p>	
TABLE																			
Sample	Ult. t.s., lb																		
1	590*																		
2	600*																		
3	613*																		
4	590*																		
5	625*																		
6	640†																		
<p>RESULTS</p> <p>Joint eff. = (min. ult. t.s. of joint)/(min. ult. t.s. of cord) = 590/610 = 97%.</p> <p>or (av. ult. t.s. of joint)/(av. ult. t.s. of cord) = 603.6/638 = 94.6%.</p>																			
<p>CONCLUSIONS Although 94.6% joint efficiency using av. ult. t.s. is slightly less than the predicted 95% efficiency, a larger sample of joint would in all probability yield the 95% req.</p>																			
TESTED BY Fay Stone & Tony Bayles		DATE COMPLETED August 1, 1967																	



See Detail "C" Dwg. 1.5438
for details of materials
and joining.

Direction
of
Pull

Joint-Suspension Line to Loop Attachment

Sketch E-0082-TL/6

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Tape, Dacron, 3/4 x 550-lb min ult. t.s. - (Recap. of all testing)		PROJECT NO. E-0082	
		TEST NO. E-0082-TL/7	
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input type="checkbox"/> POINT OF FAILURE <input type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER			
TEST METHOD Similar to Federal Specification CCC-T-191b method 5100, use Tinius Olsen tension-testing machine on 2400-lb scale and 3 1/2-in. split drums - load rate 12-in./min.			
REQUESTED BY JPB	DATE REQUESTED 7/6/67	REQUEST APPD. BY JPB	DATE APPROVED 7/6/67

TABLE	Min ult. t.s., lb						
Sample#	Roll 701	Roll 702	Roll 703	Roll 704	Roll 705	Roll 706	Roll 707
1	632	592	606	592	562	590	640
2	575†	584†					
3	635†	574†					
4		670†		Roll 708	Roll 709	Roll 710	Roll 711
5		626†		638	608	608	570
6		583†		630†			611
	Av	604.8					

*Tape bought on P.O. 42109.

†Engr. reverification. All other data from Rec. Insp. test reports.

620†
630†
633
589

RESULTS Based on 24 samples of tape tested, results are as follows:

Av. ult. t.s. = 608.3 lb†

Min. ult. t.s. = 562 lb

Max. ult. t.s. = 670 lb

Δ t.s. = max - min = 108 lb

†Vendor Certification for av. strength is 582 lb.

NOTE: Tape manufactured from three separate yarn lots.

CONCLUSIONS Tape is acceptable for use intended.

TESTED BY Pay Stone &

LaRiviere

DATE COMPLETED July 26, 1967

LABORATORY TEST REQUEST/REPORT

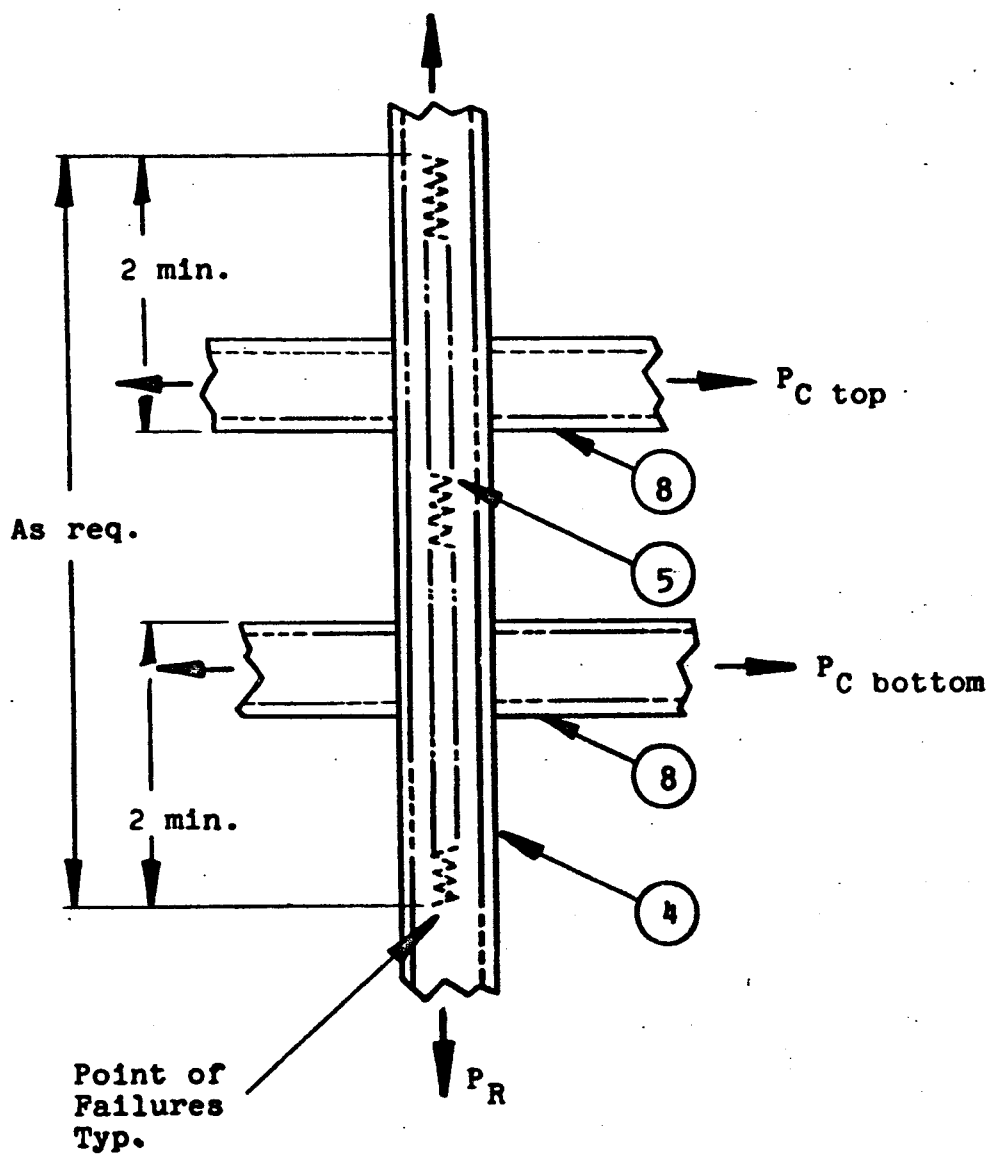
ITEM(S) TO BE TESTED Joint, radial to circumferential tape through slot (ref. Detail G Dwg. 1.5438)		PROJECT NO. E-0082	
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input checked="" type="checkbox"/> POINT OF FAILURE <input checked="" type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER		TEST NO. E-0082-TL/8	
TEST METHOD Use Tinius Olsen tension-testing machine on 2400-lb scale and with 3½-in. diam. split drums. (See attached sketch for details of test samples.)			
REQUESTED BY JPB	DATE REQUESTED 24 July 67	REQUEST APPD. BY JPB	DATE APPROVED 24 July 67

TABLE <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; width: 20%;">Test No.</th> <th style="text-align: left; width: 30%;">Ult. t.s., lb</th> <th style="width: 10%;"></th> <th style="width: 40%;"></th> </tr> </thead> <tbody> <tr> <td>P_R #1</td> <td>623</td> <td rowspan="4" style="font-size: 3em; vertical-align: middle;">}</td> <td rowspan="4" style="vertical-align: middle;">av = 624</td> </tr> <tr> <td>2</td> <td>619</td> </tr> <tr> <td>3</td> <td>627</td> </tr> <tr> <td>4</td> <td>627</td> </tr> <tr> <td>P_C top #1</td> <td>293</td> <td rowspan="3" style="font-size: 3em; vertical-align: middle;">}</td> <td rowspan="3" style="vertical-align: middle;">av = 295.5</td> </tr> <tr> <td></td> <td>297</td> </tr> <tr> <td></td> <td>287</td> </tr> <tr> <td>P_C Bottom #1</td> <td>301</td> <td rowspan="3" style="font-size: 3em; vertical-align: middle;">}</td> <td rowspan="3"></td> </tr> <tr> <td>2</td> <td>297</td> </tr> <tr> <td>3</td> <td>298</td> </tr> </tbody> </table>	Test No.	Ult. t.s., lb			P _R #1	623	}	av = 624	2	619	3	627	4	627	P _C top #1	293	}	av = 295.5		297		287	P _C Bottom #1	301	}		2	297	3	298	COMMENTS Radial Tape from Roll #702 - Test data indicates following values: Min ult. t.s. = 574 lb Max ult. t.s. = 670 lb Av* ult. t.s. = 604.8 lb Circumferential tape - roll# unknown - for 41 random samples test data indicate following values Min ult. t.s. = 279 lb Max ult. t.s. = 330 lb Av ult. t.s. = 306.5 lb *Based on 6 samples tested.
Test No.	Ult. t.s., lb																														
P _R #1	623	}	av = 624																												
2	619																														
3	627																														
4	627																														
P _C top #1	293	}	av = 295.5																												
	297																														
	287																														
P _C Bottom #1	301	}																													
2	297																														
3	298																														

RESULTS Efficiency in radial direction is
 (Min ult str joint)/(Min ult t.s. tape) = 619/574 = 107.8%.
 (Av ult str joint)/(Av ult. t.s. tape) = 624/604 = 103.3%.
 (Min ult str joint)/(Max ult t.s. tape) = 619/670 = 92.4%.
Efficiency in circumferential direction is
 (Min ult str joint)/(Min ult t.s. tape) = 287/279 = 102.8%.
 (Av ult str joint)/(Av ult t.s. tape) = 295.5/306.5 = 96.4%.
 (Min ult str joint)/(Max ult t.s. tape) = 287/330 = 87.0%.

CONCLUSIONS Joint efficiency for radial tape is within predicted values and joining method is acceptable.
 Circumferential tapes are not considered part of primary structure: they are used to prevent flutter damage.

TESTED BY Fay Stone, Bayles, LaRiviere, & Brecht	DATE COMPLETED 24 July 67
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For construction and materials details see Dwg. 1.5438
Detail "C".

Joint, Radial to Circumferential Tape Through Slot
Sketch E-0082-TL/8

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Joint, radial tape to circumferential tape through gap section. (See detail B, Dwg. 1.5438.)		PROJECT NO. E-0082	
		TEST NO. E-0082-TL/9	
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input checked="" type="checkbox"/> POINT OF FAILURE <input checked="" type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER			
TEST METHOD Use Tinius Olsen tension-testing machine on 2400-lb scale, for P_R test, and 600-lb scale on P_C test, and with $3\frac{1}{2}$ -in.-diam. split drums. (See attached sketch for details of test sample.)			
REQUESTED BY JPB	DATE REQUESTED 10 July 67	REQUEST APPD. BY JPB	DATE APPROVED 10 July 67

TABLE			COMMENTS
Test No.	Ult. t.s., lb		
P_R 1	603	} av. = 607.6	Radial tape from roll 711 - test data indicate the following data: Min. ult. t.s. = 570 lb Max. ult. t.s. = 633 lb av. ult. t.s. = 600 lb
2	600		
3	620		
P_C 1	301	} av. = 301	Circumferential tape - roll# unknown - for 41 random samples, test data indicate following values: Min. ult. t.s. = 279 lb Max. ult. t.s. = 330 lb Av. ult. t.s. = 306.5 lb
2	306		
3	296		

RESULTS Efficiency in radial direction is
 (Min. ult. str. joint)/(Min. ult. t.s. tape) = 600/570 = 105.2%.
 (Av. ult. str. joint)/(Av. ult. t.s. tape) = 607.6/600 = 101.3%.
 (Min. ult. str. joint)/(Max. ult. t.s. tape) = 600/633 = 94.8%.

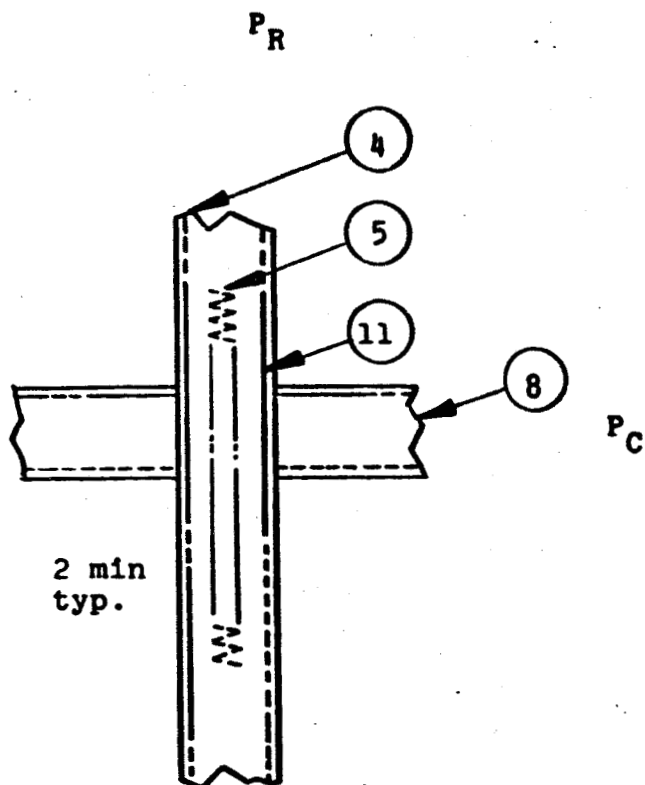
Efficiency in circumferential direction is
 (Min. ult. str. joint)/(Min. ult. t.s. tape) = 296/279 = 106.1%.
 (Av. ult. str. joint)/(Av. ult. t.s. tape) = 301/306.5 = 98.2%.
 (Min. ult. str. joint)/(Max. ult. t.s. tape) = 296/330 = 89.6%.

CONCLUSIONS Joint efficiency for radial tape is within predicted values and joining method is acceptable.

Circumferential tapes are not considered part of primary structure: they are used to prevent flutter damage.

TESTED BY Fay Stone & Tony Bayles

DATE COMPLETED August 2, 67

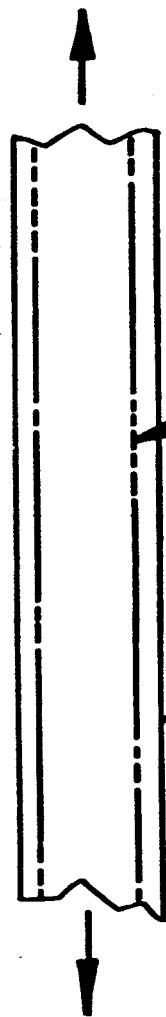


For details, see Detail "B"
Dwg. 1.5438.

Joint, Radial to Circumferential Tape Through Gap Section
Sketch E-0082-TL/9

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Radial tape through gap area.		PROJECT NO. E-0082													
		TEST NO. E-0082-1L/10													
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input type="checkbox"/> POINT OF FAILURE <input type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER															
TEST METHOD Use Tinius Olsen tension-testing machine on 2400-lb scale, with 3½-in.-diam. drums, and load rate of 10 in./min. (See attached sketch.)															
REQUESTED BY JPB	DATE REQUESTED 13 July 67	REQUEST APPD. BY JPB	DATE APPROVED 13 July 67												
<table border="1"> <thead> <tr> <th>TABLE</th> <th></th> </tr> <tr> <th>Test No.</th> <th>Ult. t.s., lb</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>642</td> </tr> <tr> <td>2</td> <td>642</td> </tr> <tr> <td>3</td> <td>635</td> </tr> <tr> <td>Av.</td> <td>639.6</td> </tr> </tbody> </table>		TABLE		Test No.	Ult. t.s., lb	1	642	2	642	3	635	Av.	639.6	<p>COMMENTS</p> <p>Tape was from roll 708. (Control samples failed at 620 lb min, 630 lb max. and 626.6 lb av.)</p>	
TABLE															
Test No.	Ult. t.s., lb														
1	642														
2	642														
3	635														
Av.	639.6														
<p>RESULTS</p> <p><u>Efficiency of radial tape is</u></p> <p>(Min. ult. str. of sample)/(Min. ult. str. of tape) = 635/620 = 102%.</p> <p>(Av. ult. str. of sample)/(Av. ult. str. of tape) = 639.6/626.6 = 102%.</p> <p>(Min. ult. str. of sample)/(Max. ult. str. of tape) = 635/630 = 101%.</p>															
<p>CONCLUSIONS Test results indicate that there is no strength loss as a result of stitching.</p>															
TESTED BY Bayles & Fay Stone		DATE COMPLETED August 2, 67													



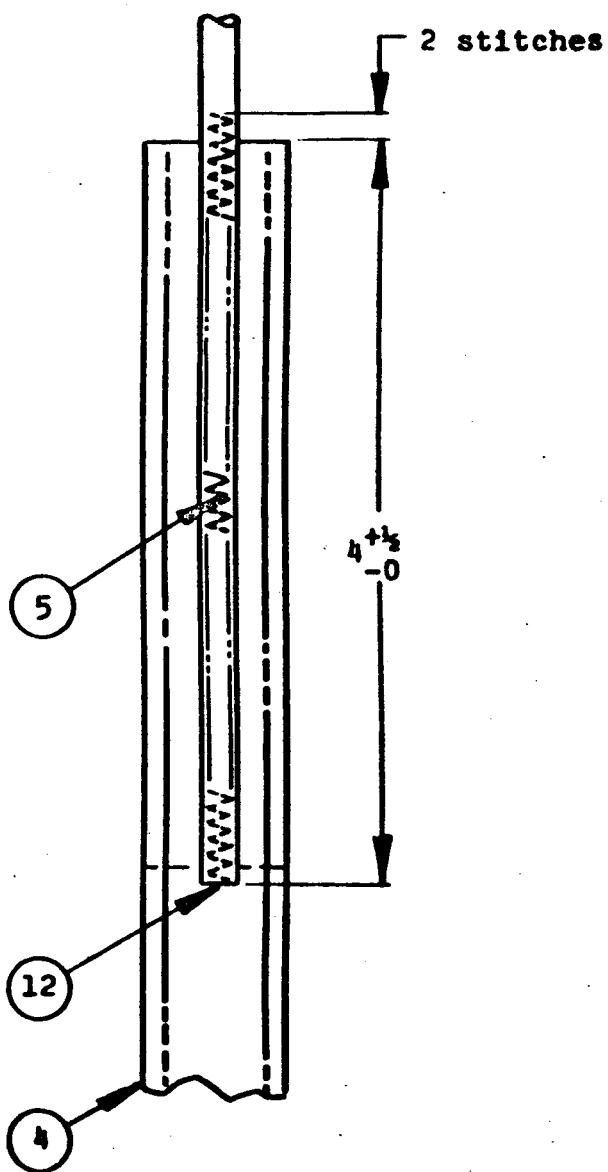
3/4 x 550 lb
Dacron tape
Pioneer Spec. 66-5, Type II

Dacron thread
size F, 5/8 in.
gauge 2-needle
stitching

Joint, Radial Tape Through Slots and Gap
Sketch E-0082-TL/10

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Joint, vent line to radial tape.		PROJECT NO. E-0082											
		TEST NO. E-0082-TL/11											
PURPOSE <input checked="" type="checkbox"/> ULTIMATE STRENGTH <input checked="" type="checkbox"/> POINT OF FAILURE <input checked="" type="checkbox"/> EFFICIENCY <input type="checkbox"/> OTHER													
TEST METHOD Use Tinius Olsen tension-testing machine, 2400-lb range, 12-in/min load rate and 3½-in. split drums.													
REQUESTED BY JPB	DATE REQUESTED 22 June 67	REQUEST APPD. BY JPB	DATE APPROVED 22 June 67										
<table border="1"> <thead> <tr> <th>Test no.</th> <th>Ult. t.s., lb</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>606</td> </tr> <tr> <td>2</td> <td>590</td> </tr> <tr> <td>3</td> <td>602</td> </tr> <tr> <td>Av.</td> <td>599</td> </tr> </tbody> </table>		Test no.	Ult. t.s., lb	1	606	2	590	3	602	Av.	599	COMMENTS Cord from unknown roll no. Min. ult. t.s. of cord was 610 lb.	
Test no.	Ult. t.s., lb												
1	606												
2	590												
3	602												
Av.	599												
RESULTS Efficiency of joint is (Joint t.s. min)/(min ult t.s. of cord) = 590/610 = 96.7%.													
CONCLUSIONS Joint efficiency used in preliminary design stress report (95%) appears to be reasonable.													
TESTED BY J.P. Brecht		DATE COMPLETED 4 August 67											



For details, see Dwg. 1.5438, Detail "A".

Joint, Vent Line to Radial Tape
Sketch E-0082-TL/11